CalComp Model 565
Digital Incremental Plotter
Instruction Manual

technical manual

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MODEL 565
DIGITAL INCREMENTAL PLOTTER
INSTRUCTION MANUAL

NOVEMBER 1974

CALCOMP
California Computer Products, Inc.
2411 W. La Palma, Anaheim, CA 92801

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SECTION 1

GENERAL DESCRIPTION

This manual contains operation and service instructions for the Model 565 Digital Incremental Plotter, manufactured by California Computer Products, Inc., Anaheim, California. The manual also contains a detailed description of the theory of operation, a parts list, and a complete set of schematic diagrams.

An overall view of the equipment is shown in Figure 1-1, and a simplified functional diagram in Figure 1-2.

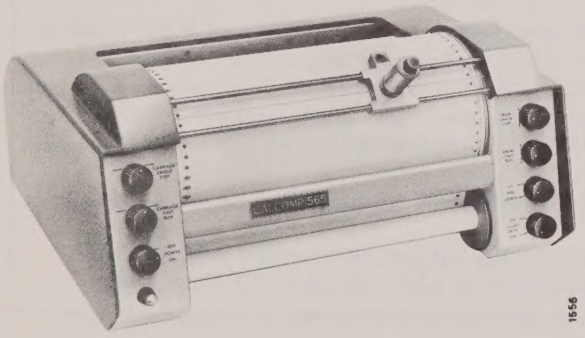


Figure 1-1. CalComp Model 565 Digital Incremental Plotter

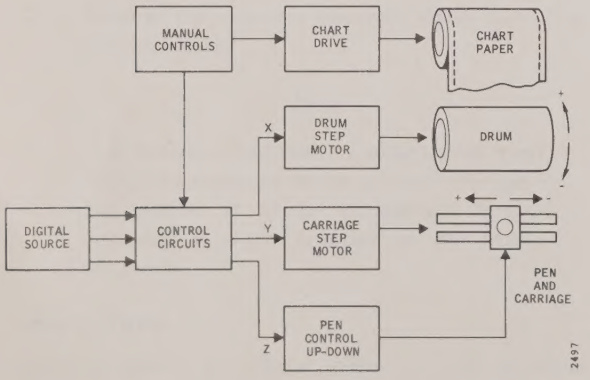


Figure 1-2. Functional Diagram

The Model 565 is a high-speed drum plotter designed for plotting one variable against another. The instrument responds to digital incremental signals from any suitable source. The actual plot is produced by the movement of a pen over the surface of the chart paper.

The Y-axis plot is produced by lateral movement of the pen carriage and the X-axis plot by rotary motion of the chart drum. Provision for Z-axis modulation is also incorporated through the use of a pen solenoid which permits the pen to be lifted or lowered in response to electrical input signals.

The plotter employs a bidirectional rotary step motor on both the X- and Y-axis drives. Each step causes the drum or pen carriage to move one fixed-length increment in either a positive or a negative direction. The size of this increment can be 0.010 inch, 0.005 inch, or 0.1 mm depending on the ratios of the gears used for the drum and carriage drives. The step motors are capable of operating at a rate up to 300 steps per second.

A roll paper feed and takeup mechanism is provided which accepts chart paper rolls 12 inches wide by 120 feet long. The feed and takeup mechanism is bidirectional. The paper is driven by pins on the drum which engage holes on both edges of the paper, thus maintaining accurate registration between the recording pen and the paper. If desired, single sheets of chart paper may be used for plotting instead of the roll paper supplied.

Twelve signal inputs are available, so that signals of either positive or negative polarity may be used to actuate the plotter in each of the six operating modes: drum up, drum down, carriage left, carriage right, pen up, and pen down. In addition, there are switches on the operator control panel for manual selection of these modes. All electrical inputs are capacitively coupled inside the plotter, thereby eliminating dependence on absolute voltage levels.

The Model 565 is completely transistorized, with most of the electronic circuitry mounted on a removable etched circuit board and a plug-in power supply assembly. The unit operates from any source of 115-volt, 50- or 60-Hz, single-phase power capable of delivering 1.5 amps.

The Digital Incremental Plotter can be used for online operation with a number of general-purpose digital computers. A special adapter is used to convert the

computer output signals to a form suitable for driving the plotter. When the Model 565 is used as an integral part of a CalComp Model 470, 750, or 760 Magnetic Tape Plotting System, the special adapter is not required.

Specifications for the Model 565 are listed in Table 1-1.

TABLE 1-1. SPECIFICATIONS

SPEED:	Drum axis: 300 steps per second maximum.
	Carriage axis: Same as drum axis.
	Pen: 10 operations, 5 up and 5 down per second maximum.
STEP SIZES:	0.01 or 0.005 inch, or 0.1 mm on both drum and carriage.
RESOLUTION:	±1 step on either axis over entire 120-foot roll of paper.
INPUTS:	Pulses of either positive or negative polarity with amplitude in excess of 10 volts, rise time less than 10 microseconds, minimum width of 4 microseconds, from a source impedance of less than 500 ohms (input circuits may be modified for specific pulse characteristics).
POWER:	105 to 125 volts, 50 or 60 Hz, single-phase (1.5 amps at 115 volts).
WEIGHT:	33 pounds.
SIZE:	Width — 18 inches.
	Depth — 14-3/4 inches excluding mating connectors.
	Height — 9-3/4 inches to top of pen holder.
PAPER SIZE:	Roll chart paper — 12 inches wide, 120 feet long; right sprocket holes 0.130-inch diameter and left sprocket holes 0.130 by 0.282 inch, all on 0.375 inch centers.

SECTION 2

INSTALLATION

The Model 565 Digital Incremental Plotter is shipped in a single packing container. Installation of the unit is simple and requires no special tools or test equipment. The plotter is completely self contained and may be operated on any level surface that is not subject to excessive vibration.

Special adapter units are provided for online operation of the Model 565 with general-purpose digital computers. Installation instructions are included in the manuals supplied with the adapters.

UNPACKING

The Model 565 is shipped completely assembled except for the pen assembly which is packed separately within the shipping container. A roll of chart paper is installed on the rear chart spool. Separate rolls of chart paper are supplied in separate boxes within the shipping container.

To unpack the unit, proceed as follows:

1. Remove the top half of the molded polyurethane foam liner that surrounds the plotter and accessories. Lift the plotter and accessories from the lower piece of polyurethane foam packing, remove the polyethylene wrapping, and the plotter is ready for installation.

2. Remove the accessory packages; check items against the packing slip.

Note

It is recommended that the shipping container, liner, and accessory boxes be stored for use if the plotter is to be transported between operating sites or returned to the factory for service.

INSPECTION

After unpacking the plotter, check for signs of physical damage in shipment. Make certain that all operator control panel switches are secure on the control shafts. Check that the pen carriage can be moved freely by hand across its track, and that the drum can be rotated manually on its axis.

CABLE FABRICATION

A female cable connector is supplied with the unit. This connector mates with chassis connector P5 on the rear of the Model 565. (See the rear view of the plotter in Section 5 for the location of the connector.) A signal cable of desired length to interconnect the plotter and the digital signal source can be made by following the signal nomenclature for connector P5 as shown in the main assembly schematic diagram in Section 3.

CHART PAPER INSTALLATION

To install the chart paper shipped on the rear chart spool, pull the end of the paper over the drum so that the holes on both edges of the paper engage the sprockets on the drum. Guide the chart paper under the carriage rods behind the tear bar. The chart paper winds on the takeup spool from the back; fasten the end on the spool with the tape provided in the accessory kit. Using the DRUM FAST RUN switch, wind a few turns onto the takeup spool.

Note

If the paper does not lie smoothly against the drum, or if it tends to pull diagonally so that the pin holes do not engage properly, see the Paper Feed Roll Adjustment procedure in Section 5. This condition may result from changes in humidity that have caused the paper roll to shrink or expand slightly.

To remove chart paper, grasp the paper roll and press the left idler spool to the left to compress the spring on the idler spool. To insert a new roll of chart paper, see the Chart Roll Installation procedure in Section 4.

PEN INSTALLATION

Ballpoint pen cartridges normally supplied with the recorder are black, blue, red, and green. To assemble the pen, insert the desired color pen cartridge into the plunger, then insert the pen and plunger into the pen body and install the threaded cap. Align the key on the pen body with the key slots in the carriage and press the pen assembly into the pen mounting. Tighten the knurled nut on the bottom of the pen body. The components of the various pen assemblies are illustrated in Section 5.

INSTALLATION PRECAUTIONS

The Model 565 depends on free air circulation under the base plate for proper cooling. Do not place the unit on top of any loose papers or cloth. Loose materials of this type can block the ventilating louvers in the base plate and cause overheating. In addition, the unit should not be placed on top of any other heat-producing equipment.

SECTION 3

THEORY OF OPERATION

The block diagram in Figure 3-1 illustrates the operation of the Model 565 in terms of signal flow and functional circuits. Inputs to the plotter from the digital signal source consist of drum up and drum down, carriage left and carriage right, and pen up and pen down pulses. These three groups of signals are generally referred to as the X-axis, Y-axis, and Z-axis signals, respectively.

The control circuits of the Model 565 are designed so that either positive-going or negative-going pulses can be utilized to produce the incremental stepping action and to control the pen solenoid. Separate signal lines are provided for positive and negative inputs to the control circuits, so that these operations may be used in any combination.

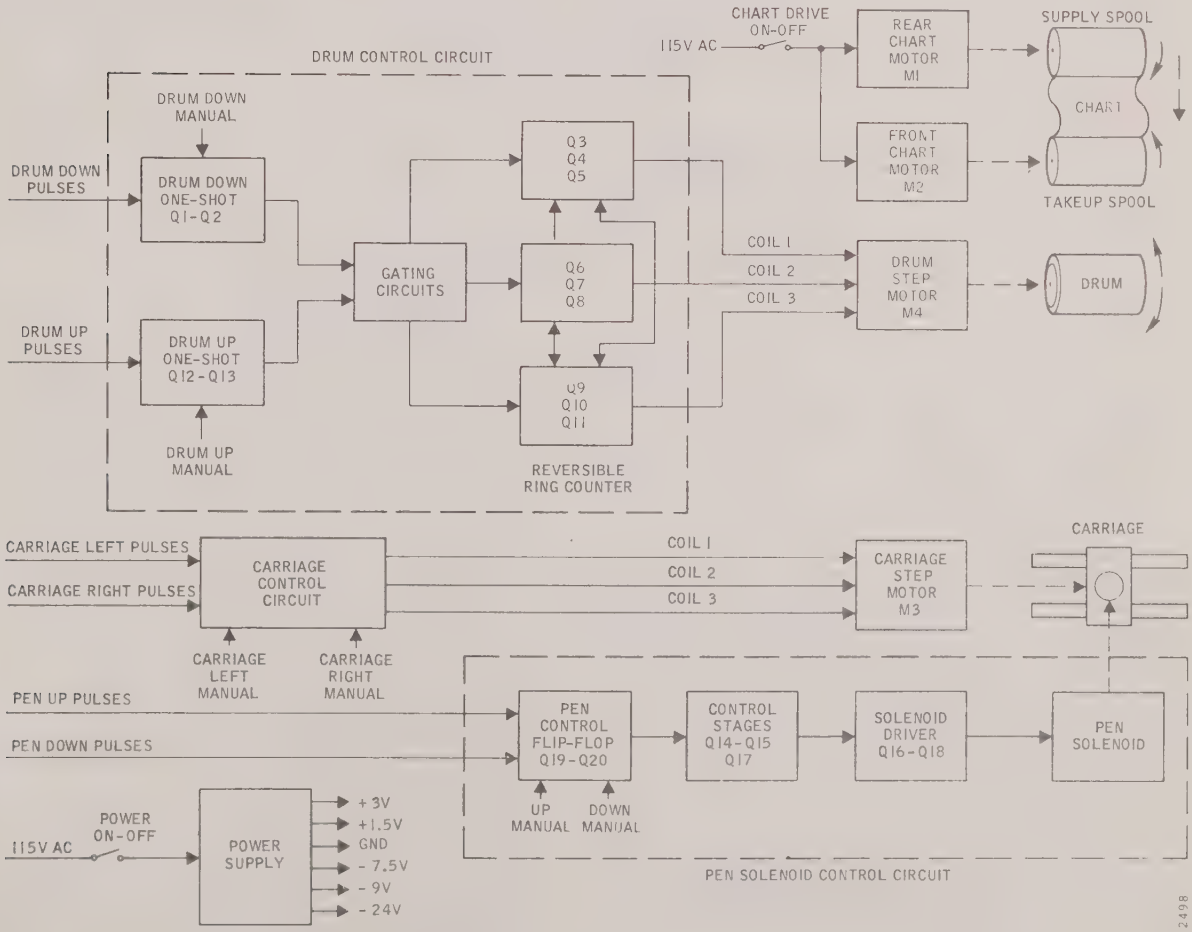


Figure 3-1. Detailed Block Diagram

The X-axis signals from the digital source are applied to separate one-shot multivibrators which in turn control the action of a reversible ring counter through suitable diode gating circuits. The ring counter consists of three stages, each of which supplies current to one pair of stator coils in the drum step motor. The design of the ring counter is such that only one pair of coils can receive current at any given time. When an incoming pulse causes one of the one-shots to be triggered, the one-shot causes the ring counter to change state. The direction of change depends upon whether the incoming pulse was a drum up or a drum down signal.

When the ring counter changes state, the step motor current is switched from one pair of coils to an adjacent pair causing the motor to rotate one-twelfth of a revolution clockwise or counterclockwise. The drum step motor is connected to the drum through a reduction gear train.

Manual positioning of the drum is provided by two operator control panel switches which allow the drum to be advanced up or down in single steps, or continuously at the rate of 120 steps per second.

The Y-axis signals from the digital source are applied to the carriage control circuit. This circuit and the carriage step motor are identical to the drum control circuit and step motor described above. Operator control panel switches are also provided for manual positioning of the carriage.

The Z-axis signals from the digital source are utilized to control a pen solenoid which, when energized, lifts the pen off the chart. The incoming pen up and pen down pulse signals are applied to a bistable multivibrator (flip-flop). The flip-flop acts as an electronic switch that controls current to the pen solenoid through suitable control stages and a current driver. Manual control of the pen solenoid is provided by means of an operator control panel switch.

The remaining functional circuits of the Model 565 are the chart takeup motors and the power supply. The chart motors operate in a stalled condition to maintain proper tension on the chart spools. An operator control panel on-off switch is provided to allow the chart motors to be disabled when a single sheet of graph paper is used in place of the continuous roll. (See operating instructions in Section 4).

The power supply consists of a silicon bridge rectifier and filter-divider components. The supply provides two positive and three negative output voltages, referenced to a circuit ground that is isolated from the plotter chassis. The dc output voltages from the power supply are:

Nominal	Actual*
+ 3.0	+ 3.2
+ 1.5	+ 2.2
- 7.5	- 7.1
- 9.0	- 8.5
-24.0	-22.0

*Voltage levels measured with a dc voltmeter

SCHEMATIC DIAGRAMS AND CIRCUIT BOARD

A simplified schematic diagram of the drum step motor is shown in Figure 3-2. Figure 3-3 illustrates the physical layout of the printed circuit board which contains the drum, carriage, and pen solenoid control circuits. The schematic diagram for the circuit board is divided into three sections, corresponding to the three functional circuits. The drum control, solenoid control, and carriage control circuits are shown in Figures 3-4, 3-5, and 3-6, respectively. The schematic diagram for the main chassis, the control panel and the power supply subassembly is shown in Figure 3-7.

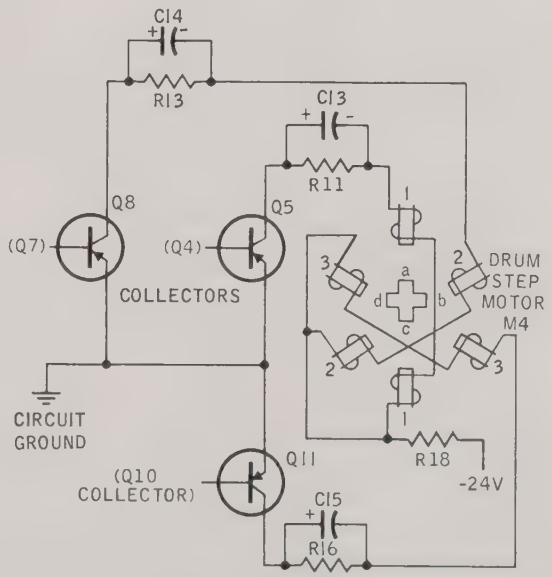
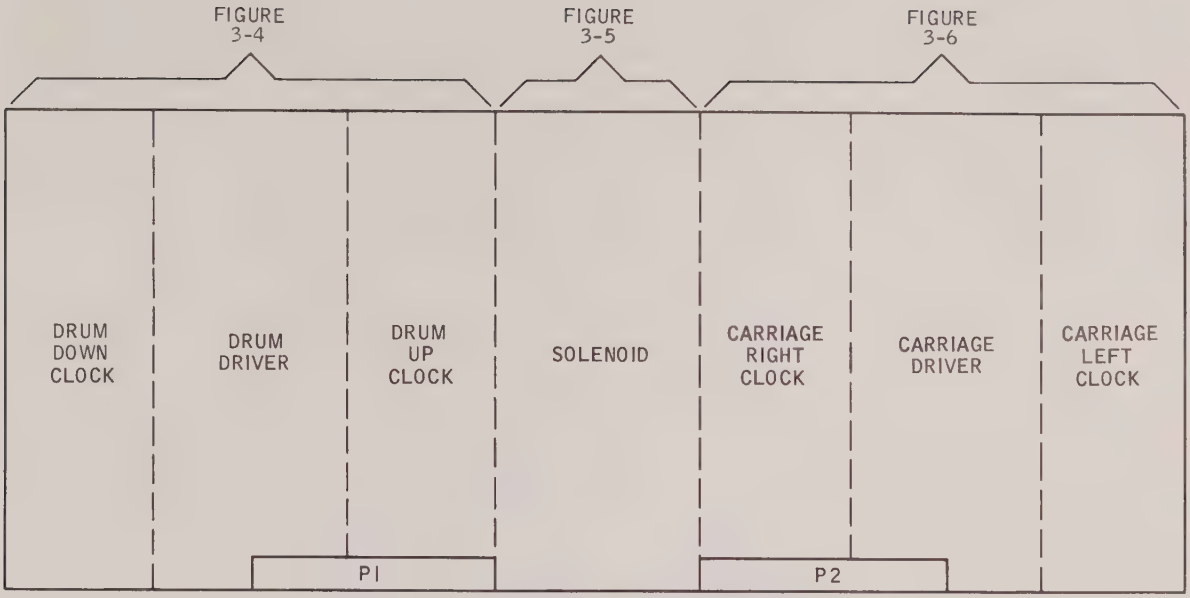


Figure 3-2. Step Motor Drive Circuit, Simplified Schematic

STEP MOTORS

Each step motor (Figure 3-2) consists of a stator with three pairs of poles arranged symmetrically around a four-pole soft iron rotor. Each of the three pairs of poles has a separate current winding that is controlled by a transistor current driver. The motor advances one-twelfth of a



PLOTTER CIRCUIT BOARD LAYOUT
(COMPONENT SIDE)

NOTES (FIGURES 3-4, 3-5, AND 3-6)

1. UNLESS OTHERWISE SPECIFIED:
   ALL RESISTOR VALUES ARE IN OHMS ± 5%, 1/2 WATT
   ALL TRANSISTORS ARE 2N1304
   ALL DIODES ARE 1N99
   ALL CAPACITORS ARE 0.01 MF ± 10% 200V
2. REFERENCE DESIGNATIONS R2, R13, R41, R52, R65, R67, R85, R87, R89, R100, AND R128 ARE NOT USED
3. R11, R50, R72, R80, R98, AND R137 ARE NOT REQUIRED
4. C30 THROUGH C41 ARE LOCATED OUT OF SEQUENCE

2500A

Figure 3-3. Circuit Board Layout

revolution each time the current is switched off in one stator winding and switched on in another winding. The direction of rotation is determined by the sequence in which the windings are energized.

For illustrative purposes, the three pairs of stator windings shown in Figure 3-2 are numbered 1, 2, and 3; the four poles of the rotor are designated a, b, c, and d. Assume that driver stage Q5 is conducting. The circuit is designed so that when Q5 conducts, Q8 and Q11 are cut off. Current therefore flows only in stator winding 1. This current creates a magnetic field which holds poles a and c of the rotor in alignment with the number 1 stator poles. If transistor Q5 is now switched off and Q8 is switched on, the rotor will turn until one pair of its poles is aligned with the poles of stator winding 2. Since poles b and d are the closest to the number 2 stator poles, the rotor will step counterclockwise.

In the above example, if driver stage Q11 were switched on instead of Q8, the rotor would step clockwise until poles b and d were in alignment with the poles of stator winding 3.

From the foregoing it can be seen that if the current is continuously switched between windings in a clockwise sequence (i.e., 1-2-3-1-2-3 . . .), the rotor will step counterclockwise. Conversely, if the switching sequence is counterclockwise, the rotor will step clockwise.

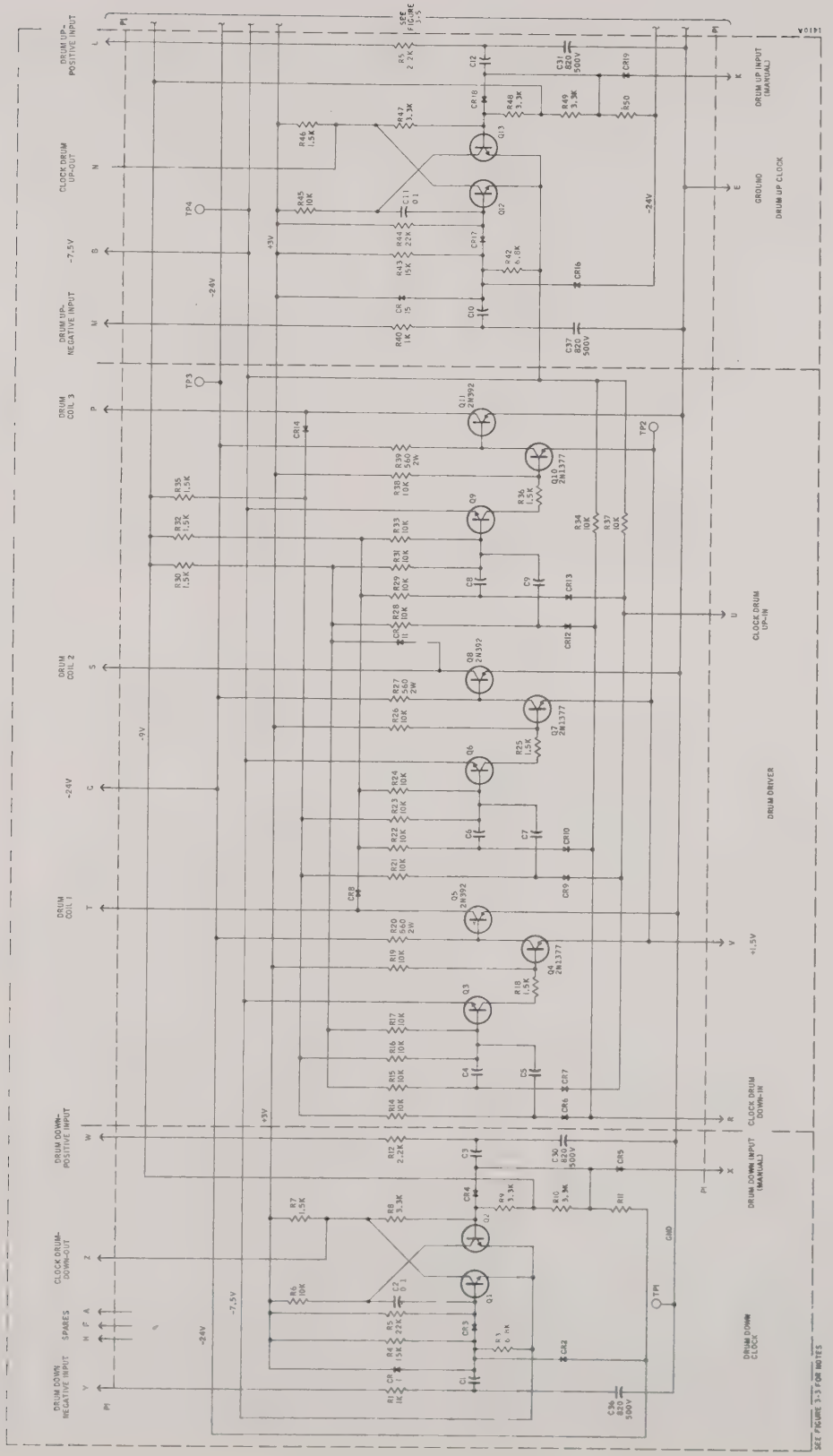


Figure 3-4. Drum Step Motor Control Circuits, Schematic Diagram

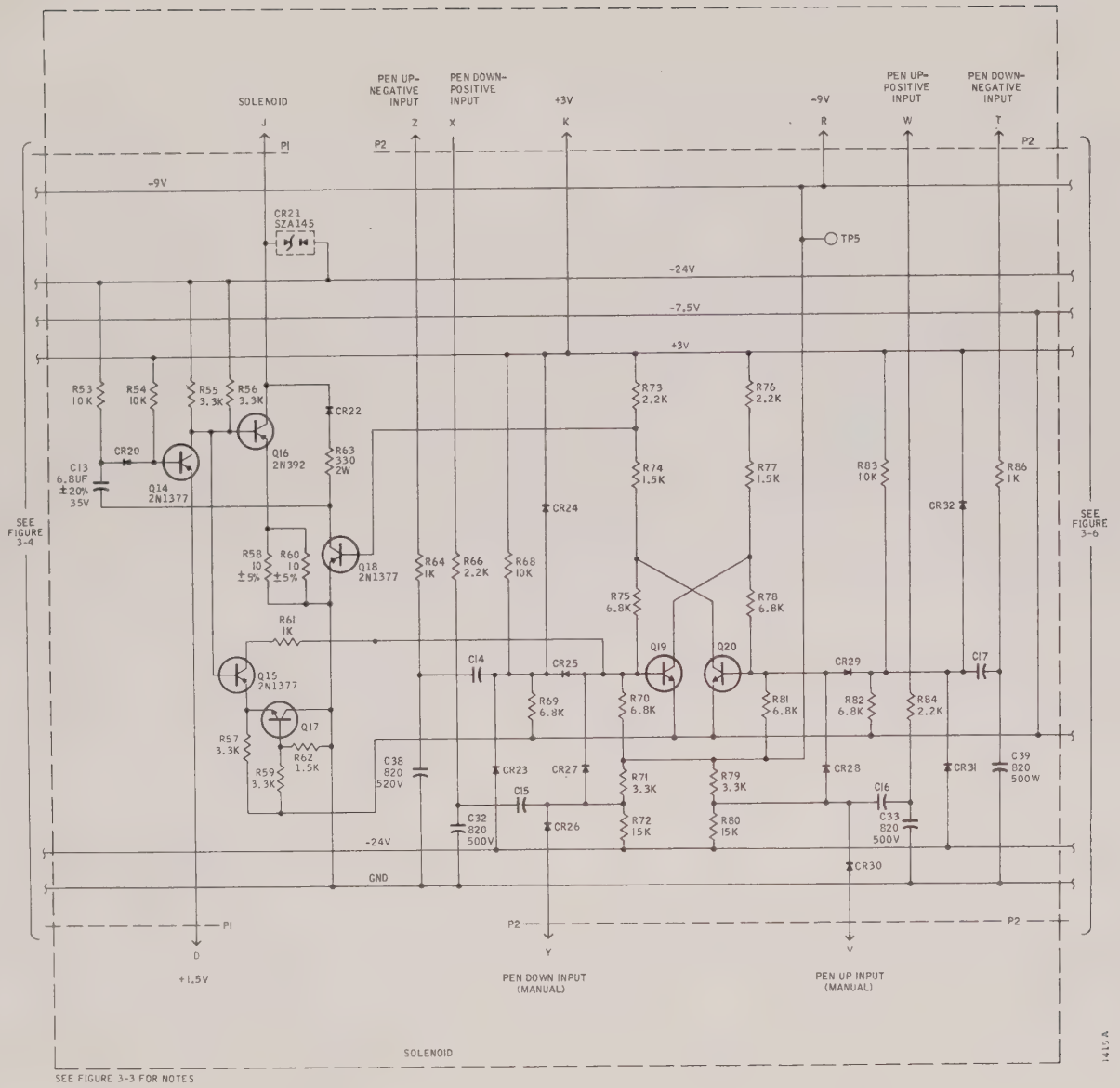


Figure 3-5. Pen Solenoid Control Circuits, Schematic Diagram

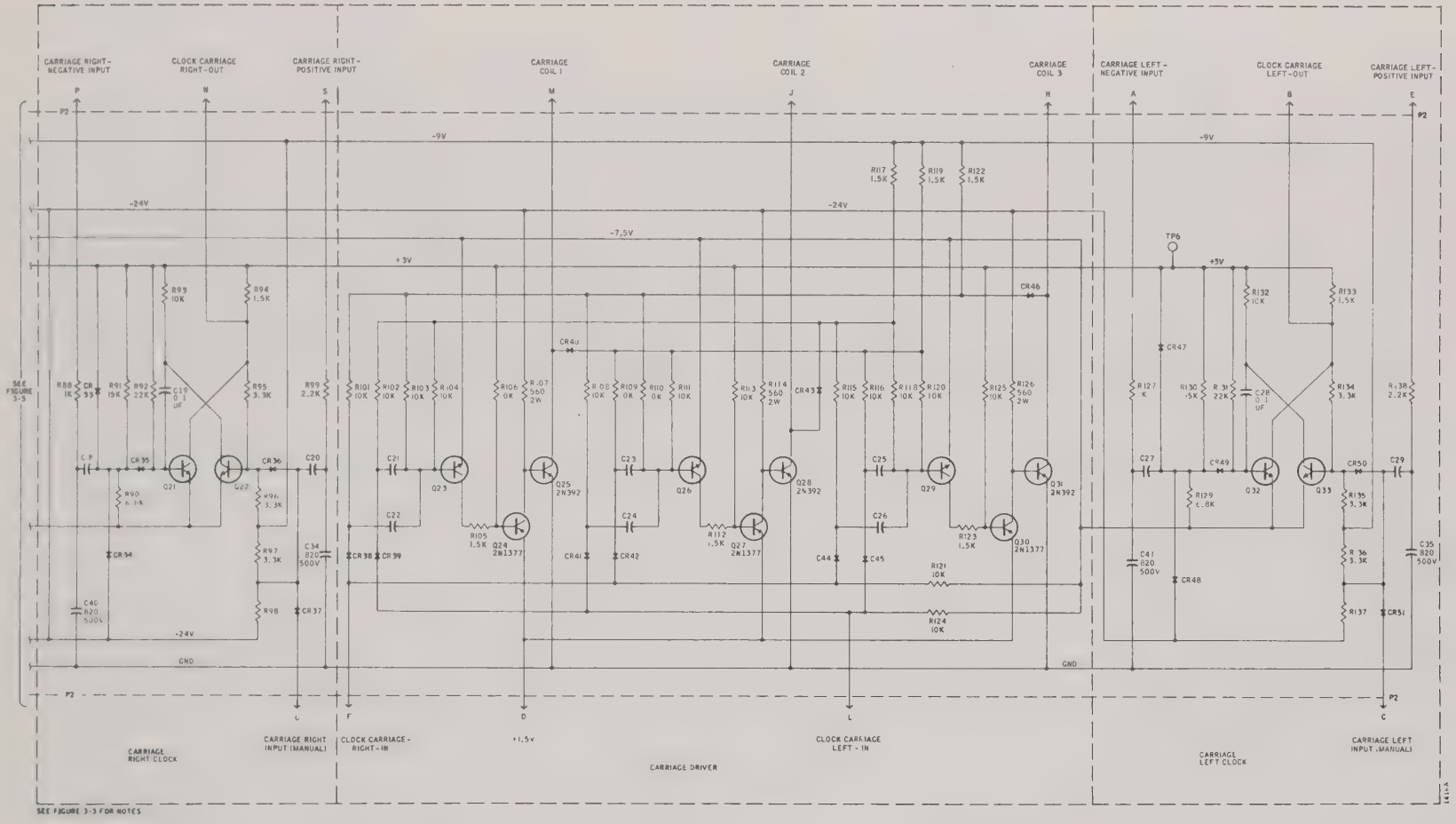


Figure 3-6. Carriage Step Motor Control Circuits, Schematic Diagram

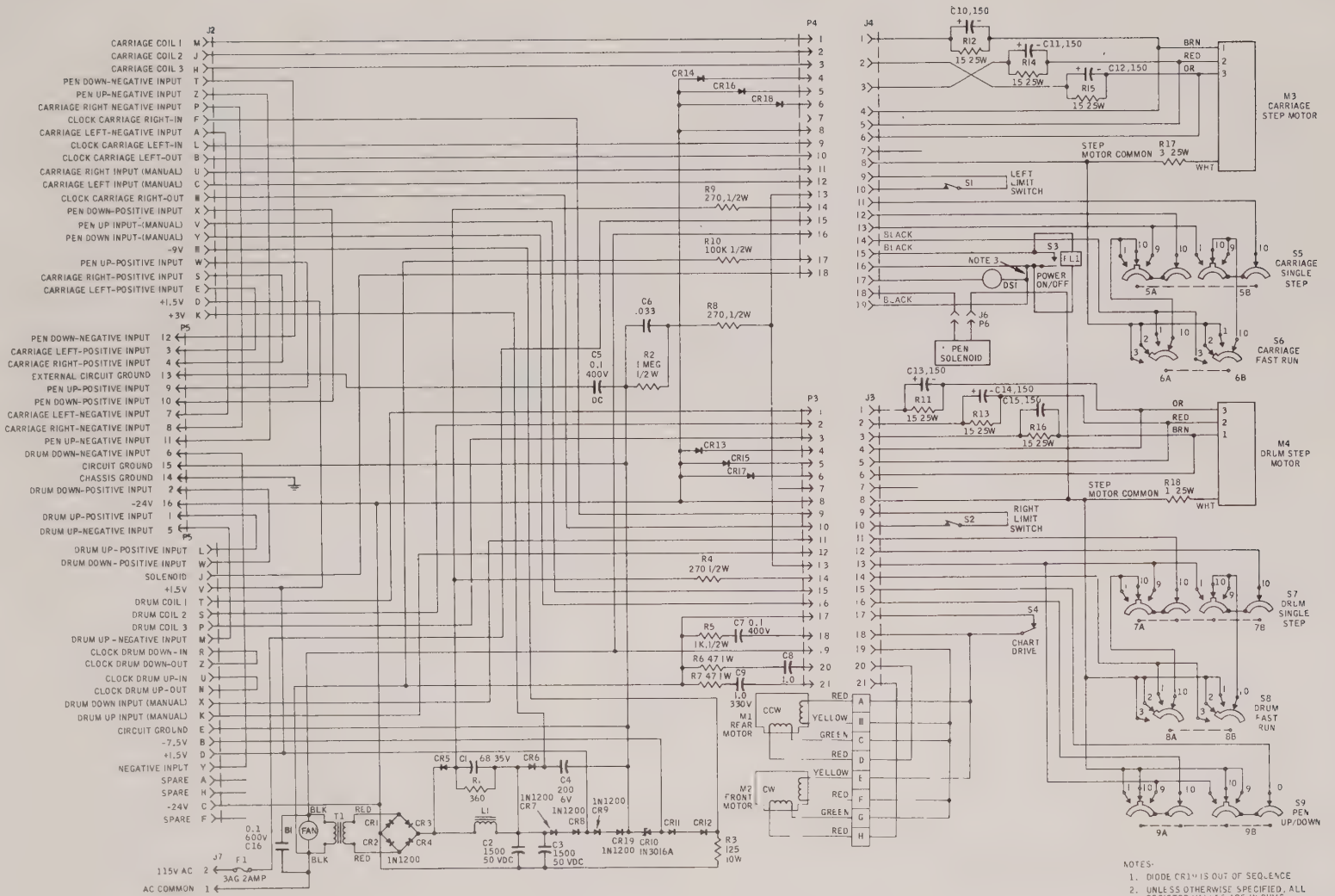


Figure 3-7. Main Assembly, Schematic Diagram

The rotor shaft of the drum step motor is coupled to the drum through a reduction gear train. The gear train determines the step size of the plotter.

The mechanical and electrical design of the carriage step motor and its associated circuit are identical to that of the drum step motor. On both motors, the pinion is mounted off center to permit the backlash between the pinion and the drum or carriage gear to be adjusted to zero.

Resistors R11, R13, and R16, shown in Figure 3-2, are current limiters. The corresponding limiting resistors for the carriage step motor are R12, R14 and R15. Across each of these resistors is a capacitor to provide proper wave shaping and acceleration of the step motor. C13, C14 and C15 are the drum step motor capacitors, and C10, C11 and C12 are the carriage step motor capacitors. Additional limiting resistor R18 is in series with the common line to the drum step motor; R17 is the corresponding resistor in the carriage step motor circuit.

A suppression diode is connected across each of the three windings in both step motors to damp out the high counter-emf generated by the decaying magnetic field when the current is switched off. The suppression diodes, shown in Figure 3-7, are CR14, CR16, and CR18 for the carriage step motor and CR13, CR15 and CR17 for the drum step motor.

REVERSIBLE RING COUNTERS

The carriage and drum step motors described in the preceding paragraphs are each driven by a reversible three-stage ring counter. The ring counter associated with the drum step motor consists of transistors Q3 through Q11 (Figure 3-4). The ring counter for the carriage step motor consists of transistors Q23 through Q31 (Figure 3-6). Since the two circuits are identical, only the drum ring counter circuits will be described.

Referring to Figure 3-4, assume that transistor current driver Q5 is conducting, supplying current to coil 1 of the drum step motor. Since only one driver stage can be in conduction at any given time, Q8 and Q11 are cut off. In the absence of a clock pulse from the drum up or drum down one-shot multivibrator, the ring counter is held in this state in the following maner: Control Stage Q3, an NPN transistor, is nonconducting, since its emitter is connected to -7.5 volts and its base is returned to -9 volts through R16-R35 and R17-R30. The base potential is held at approximately -8.5 volts. Since no collector current can flow in Q3, the base of Q4 is held at approximately +3 volts, through resistor R19. The emitter of Q4, a PNP transistor, is returned to +1.5 volts. Thus, Q4 is also nonconducting. Since there is no collector current through Q4, the base of Q5 is biased negative with respect to its emitter and Q5 conducts.

Since the emitter of Q5 is at ground potential and the step motor coil is returned to -24 volts (see Figure 3-2), the collector of Q5 will be at approximately ground potential while this stage is conducting. Diode CR8 conducts, since its cathode is returned to -9 volts through resistor R32. The bases of Q6 and Q9 are therefore returned to ground potential through CR8 and resistors R24 and R33, respectively. Both Q6 and Q9 are thus driven into conduction. The collector current of Q9 is supplied from the base of Q10. Consequently, Q7 and Q10 are saturated. The bases of Q8 and Q11 are at approximately 1.5 volts, and the emitters are at ground potential, hence these transistors are cut off.

Assume that with the ring counter in the state described above, a drum down clock pulse is applied at pin R of connector P1. Pin R is normally at approximately -7 volts, and is driven positive to essentially ground potential during the clock pulse period of approximately 1500 microseconds. This positive-going pulse is applied to the cathodes of diodes CR6, CR10, and CR12, but will affect only CR10. The anodes of CR6 and CR12 are returned to -9 volts through resistors R14—R35 and R28—R30 respectively. Thus, these diodes were initially cut off and will remain cut off during the clock pulse period. However, CR10 was initially conducting, since its associated resistor R22 is returned to ground potential through diode CR8 and conducting driver stage Q5. Capacitor Q6 is therefore initially uncharged, with about -7 volts on each side. The positive-going clock pulse at the cathode of CR10 cuts off the diode and C6 charges through R22 and the base-to-emitter circuit of Q6. At the end of the clock pulse, when the voltage at pin R returns to -7 volts, the clock pulse is capacitively coupled through C6, causing a negative-going pulse to appear at the base of Q6. This negative pulse cuts off Q6, which in turn cuts off Q7 and allows Q8 to conduct, supplying current to coil 2 of the drum step motor.

The collector of Q8 is now at ground potential, and resistors R17 and R31 are therefore returned to ground potential through diode CR11, causing both Q3 and Q9 to conduct. Q4 and Q10 also conduct, switching Q5 off and keeping Q11 cut off in the manner described previously. Gating diodes CR6 and CR10 are now cut off and CR12 is conducting. Thus, if another drum down clock pulse is applied to the circuit, capacitor C9 will drive the base of Q9 negative and Q11 will conduct.

The gating diodes associated with the clock drum up signal input at pin U of P1 are CR7, CR9 and CR13. The action

of this circuit is the same as that of the clock drum up circuit, except that the counter changes state in the reverse direction when a clock pulse is applied at pin U.

ONE-SHOT (CLOCK PULSE) MULTIVIBRATORS

The clock drum up and clock drum down signals which control the ring counter circuit described above are provided by one-shot multivibrator circuits. A separate multivibrator is provided for the drum up and drum down functions, and for the carriage left and carriage right functions. The multivibrators for these four functions, shown schematically in Figures 3-4 and 3-6, are Q1–Q2, Q12–Q13, Q21–Q22, and Q32–Q33, respectively. Since all four circuits are identical, only the drum down circuit will be described in detail.

The purpose of the one-shot multivibrator is to provide isolation between the digital signal source and the ring counter circuits, and to provide a time delay during which the circuit will not accept another step signal. This delay period, equal to 1500 microseconds, protects the ring counter against double stepping due to transients or noise.

As shown in Figure 3-4, either a positive-going or a negative-going signal may be used to trigger the drum down multivibrator. In the absence of an input signal from the digital source, transistor Q1 is normally conducting and Q2 is cut off. The regenerative cycle may be initiated by applying a negative pulse to the base of Q1, cutting off this stage, or by apply a positive pulse to the base of Q2, driving this stage into conduction. Conventional cross coupling holds Q1 cut off and Q2 in conduction for a period of time determined by the RC time constant of C2 and R5. This period is set to a nominal value of 1500 microseconds. When the base potential of Q1 decays to a value equal to the emitter potential, this stage again conducts and its negative-going collector voltage cuts off Q2. The circuit then remains in its original state until another trigger pulse is received.

Assume that a negative input signal is to be used to trigger the multivibrator. Negative-going pulses from the digital source are applied to pin Y of connector P1. Resistor R1 and capacitor C36 form a voltage divider and rf filter across the input signal line. The negative signal is coupled by capacitor C1 to the junction of resistors R4 and R3 which form a voltage divider between +3 volts and -7.5 volts. The voltage divider establishes a bias level at the cathode of diode CR3 which determines the minimum signal amplitude required to trigger the multivibrator.

Diodes CR1 and CR2 function as positive and negative clamps to prevent very large voltage spikes from damaging the circuit components. When such spikes occur, R1 also functions as a current limiter.

If a positive input signal is to be used to trigger the multivibrator, the pulses from the digital source are applied to pin W of connector P1. Resistor R12 and capacitor C30 are equivalent to R1 and C36 in the negative input circuit. Diode CR5 functions as a negative clamp, equivalent to CR2, and the base-to-emitter diode action of Q2 serves as a positive clamp, equivalent to CR1. The voltage divider action of R10 and R11 determines the anode potential for CR4, which establishes the minimum pulse amplitude required to trigger the multivibrator.

When the multivibrator is triggered, Q1 is cut off for a period of 1500 microseconds, causing the voltage at the junction of R7 and R8 to rise from approximately -7 volts to essentially ground potential for the same 1500-microsecond period. This rise is the clock drum down signal output, which is connected from pin Z through an external jumper to pin R at the input to the ring counter circuit.

Manual drum step signals are applied to the multivibrator circuit through diode CR5. The manual input signal may consist of either a single positive-going pulse, or a continuous series of 120-Hz positive-going pulses. (See Drum and Carriage Manual Control Circuits in this section.)

The operation of the carriage left and carriage right one-shot multivibrators is identical to that of the drum up and drum down multivibrators. However, the multivibrator output (clock) signals are connected to the carriage ring counter through left and right limit switches. (See Figure 3-7). The limit switches disconnect the associated multivibrator output whenever the carriage has reached the left or right limit of travel, and thus prevent further stepping action in that direction.

PEN SOLENOID CONTROL CIRCUIT

The schematic diagram for the pen solenoid control circuit is shown in Figure 3-5. In this circuit a bistable multivibrator, or flip-flop, is used for current control instead of the one-shot multivibrators used in the step motor control circuits. The flip-flop, consisting of transistors Q19 and Q20, remains in the state to which it was set by the last signal pulse, until another signal pulse causes it to change state. The flip-flop triggering circuit is designed so that pulses of either polarity may be used to set the flip-flop to either state.

In the normal, or pen down state, Q19 is conducting and Q20 is cut off. The flip-flop can be switched to the pen up state by applying a negative trigger pulse at the base of Q19 or a positive trigger pulse at the base of Q20. Q19 will then be held cut off by the negative voltage at the collector of

Q20, and Q20 will be held in conduction by the positive voltage at the collector of Q19. The flip-flop will then remain in the pen up state until a positive trigger pulse is applied to the base of Q19 or a negative pulse to the base of Q20.

The input trigger circuits for the pen control flip-flop are similar to those used for the delay multivibrators in the drum and carriage control circuits. For example, in the pen up negative input circuit, R64 and C38 form a voltage divider and rf filter circuit. The negative signal is coupled by capacitor C14 to the junction of voltage divider resistors R68 and R69. These resistors establish the bias level for diode CR25, which determines the minimum signal amplitude required to trigger the flip-flop. Diodes CR24 and CR23 function as positive and negative clamps to protect the circuit against large voltage spikes. The input circuits for pen down positive, pen up positive, pen up negative, and pen down negative signals are similar.

Manual pen up and pen down signals are applied to the flip-flop through diodes CR30 and CR26, respectively. Both of the manual inputs consist of a single positive-going pulse. (See Pen Solenoid Manual Control Circuits in this section.)

The output voltage from the pen control flip-flop, obtained from the junction of resistors R73 and R74, is applied to the base of the driver transistor Q18. When the flip-flop is in the pen down state, Q20 is cut off and this voltage is approximately +3 volts. Q18 is therefore biased off. When the flip-flop changes state, Q20 conducts and the base of Q18 becomes negative. Q18 is driven into conduction and supplies current to the pen solenoid.

The drive transistor Q18 performs a dual function in the pen control circuit. It supplies current to actuate transistor Q14, and it supplies a continuous holding current to keep the solenoid retracted as long as the flip-flop remains in the pen up state. When Q18 is first driven into conduction, its collector voltage changes very rapidly from a negative potential to ground potential, causing a large positive pulse to be coupled through capacitor C13 to the cathode of diode CR20. Transistor Q14 is normally biased on by the voltage divider action of R54, CR20 and R53, which maintains a negative potential at the base. When the positive pulse appears at the cathode of CR20, the diode is cut off and the base of Q14 then becomes positive, since resistor R54 is returned to +3 volts. Transistor Q14 is therefore cut off and its collector voltage goes negative. Since the collector is tied to the base of Q16, this negative voltage now causes Q16 to conduct. Q16 supplies a surge of current to the pen solenoid through pin J of P1. This initial surge is sufficient to overcome inertia and lift the pen from the paper. Q14 remains cut off and Q16 conducts for a period determined by the RC time constant of C13 and R53. The voltage at the cathode of CR20 decreases exponentially as C13 charges, and when the cathode becomes more negative than +1 volt, diode CR20 will again conduct and Q14 will be driven into conduction. The collector current of Q14 produces a voltage drop across resistors R55 and R56 which cuts off Q16. At this time, only the holding current is supplied to the solenoid, through the collector of Q18, resistor R63, and diode CR22. The nominal value of holding current is approximately 35 milliamperes.

From the foregoing, it will be seen that if the pen and its solenoid are removed from the carriage while the circuit is in the pen up state, only the holding current will be supplied to the solenoid when the pen is replaced. This condition will also occur if the flip-flop assumes the pen up state when power is first applied. The pen therefore will remain down even though the flip-flop is in the pen up state and pen up signals will have no effect. In this event, the manual control must be turned first to PEN DOWN, and then to PEN UP. The pen down signal will reset the flip-flop to the down state, and the pen up signal will set it to the up state. As the flip-flop switches back to the pen up state, the initial surge of current supplied by Q16 will lift the pen.

Transistors Q15 and Q17 with their associated components comprise a protection circuit which automatically resets the flip-flop to the pen down state if a short circuit occurs at the pen solenoid. Transistor Q17 is normally conducting. Its base is biased positive with respect to the emitter by the action of R62 and R59 which form a voltage divider between ground and -7.5 volts. The emitter of Q17 establishes the emitter potential of Q15. Transistor Q15 is normally cut off by the positive bias applied to its base, which is tied to the base of Q16. If a short circuit occurs at the solenoid, Q16 will conduct and its emitter will be at some negative potential determined by the voltage drop across parallel resistors R58 and R60, causing the bases of both Q16 and Q15 to be driven negative. When the base of Q15 is more negative than the emitter voltage established by Q17, Q15 will conduct and cause a positive-going pulse to be coupled to the base of Q19, which has the same effect as a pen down signal. The flip-flop is therefore reset to the pen down state and current is cut off from the solenoid. During the short period required for this action to occur, the current through Q16 is limited to 600 milliamperes by the action of R58 and R60.

DRUM AND CARRIAGE MANUAL CONTROL CIRCUITS

The manual controls for the drum and carriage control circuits are shown in the schematic diagram of Figure 3-7. Separate controls are provided for single and continuous

stepping (fast run) of both the drum and the carriage. Since the drum and carriage controls are identical, only the drum controls will be described in detail.

The DRUM SINGLE STEP switch S7 is a spring-loaded three-position wafer switch that permits the drum to be manually advanced upward or downward in single steps. In the neutral or off position, shown in Figure 3-7, both the drum up input and the drum down input signal lines to the one-shot multivibrators are returned to -24 volts. The return path for the drum up input is from pin K of J1,through pin 12 of P3 and J3, through terminal 10 of wafer 7B on switch S7, through terminals 10 and 2 of wafer 8B on switch S8, to the -24 volt bus. The drum down input is returned to -24 volts through a similar path, from pin X of J1. If switch S7 is momentarily turned to the up position, the drum up manual input line is disconnected from -24 volts and connected through terminal 1 of wafer 7B to resistor R8, which is returned to circuit ground through resistor R2. This return to circuit ground causes a positive-going pulse to appear at J1-K, which triggers the drum up one-shot multivibrator in the manner described under One-Shot Multivibrators. Conversely, if S7 is turned to the down position, the drum down manual input at J1-X will be connected to R8 through terminal 9 of wafer 7A, causing the drum down multivibrator to be triggered. The RC network of R8 - R2 - C6 acts as a filter to prevent switching transients from causing double triggering. These components are also connected to the carriage single step circuit associated with switch S5.

The DRUM FAST RUN switch S8 is a detent three-position wafer switch that permits the drum to be continuously stepped in either direction at the rate of 120 steps per second. When the switch is in the neutral or off position, both the drum up and drum down lines are returned to -24 volts through the circuit paths described in the preceding paragraph. If switch S8 is set to the up position, the drum up input line is connected from -24 volts at terminal 2 of wafer 8B and is connected to resistor R4, through terminal 3 of wafer 8B and pin 14 of J3 and P3. Resistor R4 is connected to the unfiltered output of the bridge rectifier circuit, which provides a continuous series of pulses that vary sinusoidally from -40 volts to approximately +4 volts, at the rate of 120 Hz. Diode CR5, capacitor C1, and resistor R1 function as a waveshaping circuit. Capacitor C1 charges through CR5 on the negative voltage excursion and discharges through R1 on the positive excursion, effectively isolating the fast-run signal line from AC line and switching transients. If switch S8 is set to the down position, the action is identical, except that the drum down input line is connected to resistor R4 through terminal 1 of wafer 8A. Resistor R4 functions as a current limiting and voltage dropping resistor. Resistor R9 performs the same function for the carriage fast run circuit associated with switch S6.

PEN SOLENOID MANUAL CONTROL CIRCUIT

The manual control circuit for the pen solenoid is shown in the schematic diagram of Figure 3-7. The PEN UP/DOWN switch S9 is a spring-loaded three-position wafer switch identical to the DRUM SINGLE STEP and CARRIAGE SINGLE STEP switches S5 and S7. Operation of the switch is the same as for the drum and carriage switches. For example, when switch S9 is momentarily turned to the UP position, then the pen up input line at J2-V is disconnected from -24 volts at terminal 10 of wafer 9B and is connected to ground potential at R8, through terminal 1 of wafer 9B.

AC POWER DISTRIBUTION AND DC POWER SUPPLY

The Model 565 Digital Incremental Plotter is designed to operate from a source of 115-volt, 50 or 60 Hz, single-phase primary power. However, step-down transformer units can be obtained which permit the plotter to be operated from higher power line voltages. Listed below are the part numbers of available step-down units and the corresponding source voltages.

IC No.	Part No.	Source Voltage
374290-5	20114-501-101	208
374300-2	20114-501-111	230
374310-1	20114-501-121	240
374320-0	20114-501-131	250

Power is applied to connector J7 (Figure 3-7) mounted on the rear of the main assembly. One side of the ac line is routed through 2 amp fuse F1 and POWER ON/OFF switch S3 to cooling fan B1 and power transformer T1. The other side of the ac line is connected directly to the fan and the transformer. A front panel indicator lamp DS1 is illuminated whenever switch S3 is ON.

The cooling fan B1, mounted on the power supply subassembly, draws air in from the underside of the plotter and directs it over the silicon rectifiers, the step motors, and the chart motors.

Power transformer T1 supplies alternating current to the silicon rectifiers CR1 through CR4, which are connected in a conventional bridge circuit. The bridge rectifier provides a total dc output voltage of approximately 27 volts. Circuit ground is established at a point 3 volts below the positive side of the output. Filtering is provided by choke L1 and electrolytic capacitors C2 and C3. Diodes CR7, CR8, CR9, CR19, CR11 and CR12, Zener diode CR10, and resistor R3 make up a voltage divider network across the output. The dc supply voltages are obtained at +3, +1.5, -7.5, -9, and -24 volt taps on the divider network. Zener diode CR10 closely regulates the -7.5 volt supply which is used as a bias reference in the transistor circuits associated with the various control functions. (These voltages are ideal and may vary considerably without adversely affecting plotter operation.)

Chart takeup motors M1 and M2 are 115-volt two-phase motors which normally operate in a stalled condition to maintain the proper tension on the roll of chart paper. When CHART DRIVE switch S4 is ON, one winding of each motor is connected directly across the ac line. The second winding of each motor is connected to the ac line through phase-shifting capacitors which supply current in the correct phase relationship to produce a torque on the armature. The phase-shifting networks consist of R6 and C8 for the rear takeup motor, and R7 and C9 for the front takeup motor.

To prevent switching transients from feeding back through the power circuits, filtering elements are connected across various components. The contacts of the CHART DRIVE switch S4 are bypassed by R5 and C7, and the POWER switch S3 is bypassed by FL1, located on the base of the plotter near the carriage drive pulley. Capacitor C16 helps suppress transients originating in the fan motor and power transformer.

All input signals to the Model 565 are connected to the plotter at P5, mounted on the rear of the main chassis. The -24 volt and circuit ground buses from the internal power supply are also terminated at P5 to permit their use as reference potentials in external equipment. Capacitor C5 provides isolation between the circuit ground bus for the Model 565 and the external circuit ground whenever such isolation is required for protection of the equipment. A chassis ground exists at pin 14 of P5.

SECTION 4

OPERATING INSTRUCTIONS

This section includes functional descriptions of all operator control panel switches and indicators for the Model 565 Digital Incremental Plotter, instructions for preparation of the plotter for use, and operational checkout procedures. Since operation of the Model 565 is automatic, detailed operating instructions are not required.

CONTROL AND INDICATORS

As shown in Figure 4-1, seven operating controls and one indicator lamp are mounted on the operator control panel. Their functions are described in the following paragraphs.

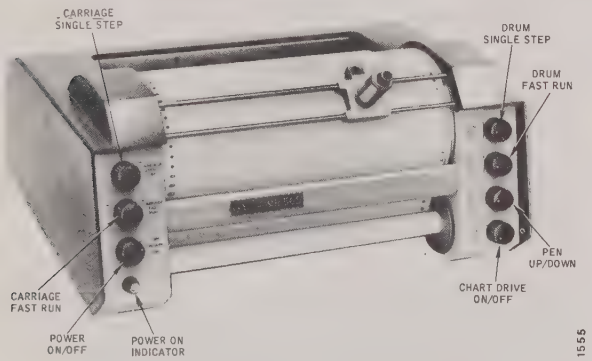


Figure 4-1. Model 565 Operator Control Panel

POWER ON/OFF Switch and Indicator

The POWER ON/OFF switch connects 115 vac power from connector J7 on the rear panel of the recorder to the cooling fan and the power supply transformer. A neon indicator, located directly below the switch, is lighted when the switch is ON.

Note

If desired, ac power to the Model 565 may be supplied through the signal connector P5, utilizing two of the spare pins. If this modification is installed, the two wires connected to J7 should be unsoldered and connected to P5. DO NOT connect jumpers from J7 to P5, since this would result in the presence of ac line voltage on the exposed prongs of J7.

CARRIAGE FAST RUN Switch

The CARRIAGE FAST RUN switch allows the pen carriage to be stepped rapidly to the left or right at the rate of 120 steps per second when using 60-Hz power, or 100 steps per second when using 50-Hz power. The switch may be used to move the carriage to any desired area of the graph or for operational checkout of the carriage control circuits and the carriage step motor.

CARRIAGE SINGLE STEP Switch

The CARRIAGE SINGLE STEP switch allows the pen carriage to be moved in single-step increments either to the left or right. This control, in combination with the DRUM SINGLE STEP control, permits the operator to align the carriage on a point or fixed coordinate on the paper.

CHART DRIVE ON/OFF Switch

The CHART DRIVE ON/OFF switch allows the operator to disable the front and rear chart takeup motors which permits the use of single sheets of chart paper in place of the paper rolls supplied with the plotter.

PEN UP/DOWN Switch

The PEN UP/DOWN switch provides a means of manually raising and lowering the pen.

Note

When the instrument is first turned on, or if the pen is removed and replaced when the plunger is in the PEN UP position, the pen may remain down even when the PEN switch is turned to UP. When this occurs, turn the PEN switch first to DOWN, then to UP. (See Theory of Operation, Pen Solenoid Control Circuit.)

DRUM FAST RUN Switch

The DRUM FAST RUN switch allows the drum to be stepped rapidly up or down at the rate of 120 steps per second. The switch is used in the same manner as the CARRIAGE FAST RUN control to move the pen to any desired area of the chart or for operational checkout of the drum control circuits and the drum step motor.

DRUM SINGLE STEP Switch

The DRUM SINGLE STEP switch allows the drum to be moved in single-step increments either up or down. This control, in combination with the CARRIAGE SINGLE STEP control, permits the operator to align the pen on a point or fixed coordinate on the chart.

CHART ROLL INSTALLATION

To install a roll of chart paper on the plotter, make sure that the paper is evenly wound on the core; i.e., that the ends are not "coned." Straighten coned rolls by tamping the end with the protruding core against a flat surface. Then proceed as follows:

1. Set the POWER switch to OFF.

2. Remove the pen assembly from the carriage by loosening the knurled nut at the bottom of the pen body and lifting the assembly out of the carriage.

CAUTION

Use care not to drop the pen assembly or any of its parts. The assembly is constructed of soft steel to close tolerances and can be rendered inoperative by nicks or dents.

3. Rotate the right rear paper spool by hand until the drive key is pointing upward.

4. Hold the new roll of chart paper so that the key slot in the core is pointing upward. Using your thumb, press the idler spool (left end) to the left, and slip the left end of the paper roll on the idler spool. Do not press the idler spool aside with the paper roll as this tends to cone the end of the roll and cause misalignment.

5. Still pressing the idler spool with your thumb, lower the paper roll into the paper well and slide the right end onto the drive spool. Make certain the drive key engages the key slot in the core.

6. Install an empty paper roll core on the two front spools below the drum in the same manner as the paper roll.

7. Pull the end of the paper over the drum so that the sprocket holes on both edges of the paper engage the sprockets on the drum. Guide the chart paper under the carriage rods and behind the tear bar. The chart paper winds on the takeup spool from the back; fasten the end of the spool with the tape provided in the accessory kit.

8. With the CHART DRIVE switch ON, set the POWER switch ON. Using the DRUM FAST RUN switch, wind a few turns onto the takeup spool.

9. Scales on the inside faces of the rear paper spools indicate the approximate number of feet of paper remaining on the roll. The black scale is for chart papers 0.003 inch thick; the blue scale is for 0.002-inch paper.

SINGLE SHEET CHART PAPER INSTALLATION

Single sheets of chart paper may be used for plotting instead of the chart paper roll. To install a single sheet of chart paper, proceed as follows:

1. Set the POWER and CHART DRIVE switches to OFF.

2. Remove the pen assembly from the carriage.

3. Slide the chart paper sheet under the carriage rods onto the drum surface.

4. Fasten the top edge of the paper to the drum with two or three short pieces of tape. Rotate the drum by hand, keeping the paper smooth and flat against the drum surface. Fasten the bottom edge of the paper in the same manner as the top.

OPERATIONAL CHECKOUT

The following procedure is intended to provide an overall check of the operation of the Model 565 prior to the start of automatic recording. If a malfunction is encountered at any point in the checkout procedure, refer to Section 5 for troubleshooting data.

1. After installing paper on the drum, install the pen assembly in its carriage.

2. Set the POWER and CHART DRIVE switches ON.

3. Turn the PEN switch to the DOWN position, then the UP position. Check that the pen lifts off the drum surface.

4. Set the PEN switch to the DOWN position, then set the DRUM FAST RUN switch to the down position. Check that the pen again traces a vertical line on the chart paper. Repeat with the DRUM FAST RUN switch in the up position.

5. Set the CARRIAGE FAST RUN switch to the left position. Check that the pen traces a horizontal line on the chart and that the carriage step motor stops

when the carriage reaches its limit of travel. Repeat with the CARRIAGE FAST RUN switch in the right position.

6. Alternately operate the CARRIAGE SINGLE STEP and DRUM SINGLE STEP switches. Check that both the carriage and the drum move one step only each time one of the switches is operated.

7. Move the carriage near the left margin of the chart paper. Set the CARRIAGE FAST RUN switch to the right position and the DRUM FAST RUN switch to the down position. Allow the plotter to run until the carriage reaches the right side of its track, then return both switches to the off (center) position. Make sure that the pen traced a 45-degree line on the chart. Check the line carefully for any evidence of discontinuity.

8. Operate the DRUM SINGLE STEP switch several time to reposition the pen either above or below its position at the end of step 7.

9. Set the CARRIAGE FAST RUN switch to the left position and the DRUM FAST RUN switch to the up position. Allow the instrument to run until the carriage reaches the left side of the track, then return both switches to the off position. Make sure that the pen traced a 45-degree line on the chart and that this line is exactly parellel to the line traced in step 7.

10. Repeat steps 7 through 9, changing the switch positions to produce two 45-degree lines at right angles to the first two. Again check for discontinuity and make certain the two lines are parallel.

CARRIAGE ALIGNMENT

Two alignment reticles are provided to permit manual alignment of the carriage to the desired zero point (Figure 4-2). One of these (20501-212-000) replaces the pen assembly and shows the exact point on which the pen will fall; the other (20502-212-000) occupies a special receptacle in the carriage, and indicates a point exactly one inch from the pen measured along the X axis in the positive direction. The latter reticle can be left in the carriage at all times. When installing either reticle, rotate it as it is inserted to prevent damage to the O-ring.

AUTOMATIC OPERATION

After the installation of chart paper, the operational checkout, and the reticle adjustment described in preceding paragraphs, the Model 565 is ready for use. Connect the digital source to P5 on the rear panel of the recorder and set the POWER switch to ON.

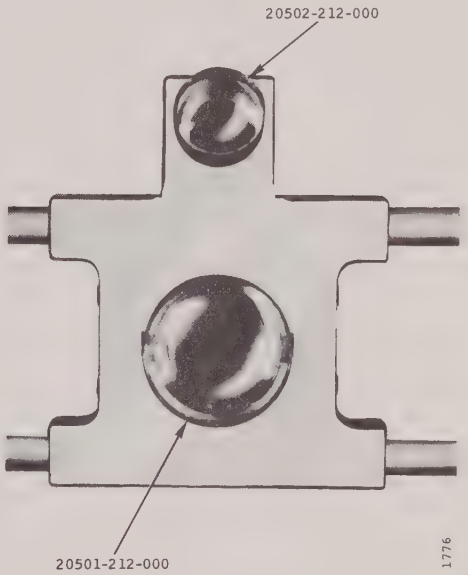


Figure 4-2. Reticle Adjustment

Note

Do not turn power off, then on again, during a recording; a plotting error of one step in any direction may result.

CHART PAPER REMOVAL

The roll of chart paper or single sheet of chart paper should be removed in the reverse sequence to the installation procedure described above. If a single sheet of chart paper is used, any remaining tape adhesive should be cleaned from the drum surface with acetone or a good grade of commercial cleaning solvent.

SECTION 5

MAINTENANCE

This section includes all necessary instructions for maintenance, repair and troubleshooting of the Model 565 Digital Incremental Plotter. Because the plotter is constructed of the highest quality materials and the most reliable electronic components, in normal use, with reasonable care, it will provide years of reliable operation with minimum service or repair.

Figures 5-1 and 5-2 shows the Model 565 disassembled to the extent required for normal maintenance.

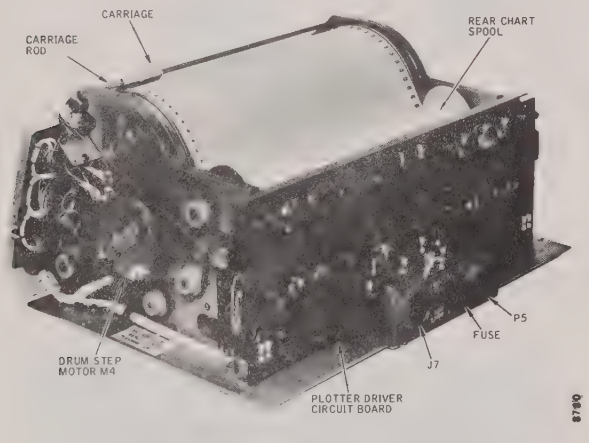


Figure 5-1. Rear View, Cover Removed

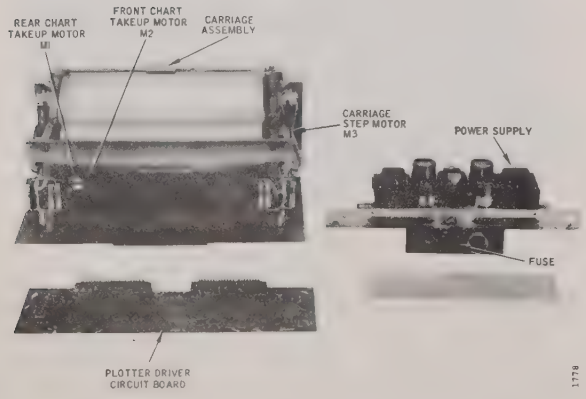


Figure 5-2. Rear View, Plug-In Assemblies Removed

ROUTINE MAINTENANCE

Routine maintenance of the Model 565 is limited to periodic cleaning and operational checkout. Lubrication is limited to the use of a small amount of light grease or vaseline on the threaded portion of the pen carriage to facilitate removal and installation of the pen assembly. Use catuion to prevent any lubricant from getting on the electrical spring contacts in the key slots on the carriage.

Since the operational checkout described in Section 4 is normally performed at the start of each recording run, this portion of the routine maintenance schedule may be omitted if the plotter is in frequent use. If the plotter is used infrequently, it is recommended that an operational checkout be performed at least once a week.

The carriage rods, the drum surface, and the metal plunger inside the pen assembly should be cleaned periodically. The intervals at which cleaning should be performed will be determined by the operating environment and the frequency of use. All normal cleaning can be accomplished with a soft, dry cloth. If necessary, the cloth may be moistened with acetone or cleaning solvent to remove foreign matter.

The most common cause of poor quality annotation is dirty carriage rods. It is recommended that rods be cleaned with a dry cloth once every eight hours of operation. Periodically, a solvent such as alcohol or acetone should be used. It may be necessary to clean the dirt accumulation from the mating surfaces inside the carriage itself. For this cleaning the cover must be removed from the plotter, and the carriage rods pulled out from one end support and out of the carriage itself. Then a cotton swab dipped in alcohol or acetone can be used to clean the inside of the carriage. The carriage need not be removed from the plotter for this cleaning. However, care should be taken not to pull the carriage so that the spring fastening the ends of the carriage cables is deformed.

Figure 5-3 illustrates various pen assemblies. The inside of the plungers of the ballpoint pen assemblies should be cleaned by pushing one corner of a cloth through the center. If a plunger is clogged, it should be dipped in cleaning solvent and then wiped dry, using a cotton swab to clean the inside of the solenoid.

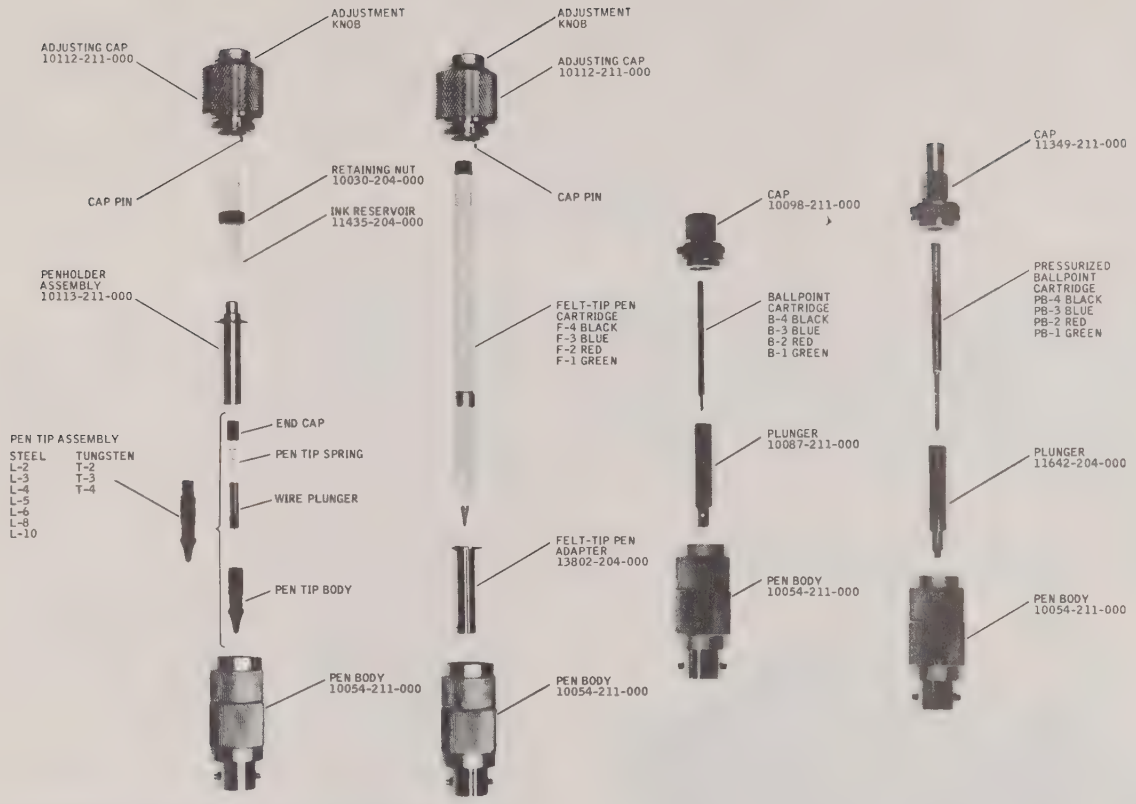


Figure 5-3. Pen Assemblies

CAUTION

Use care to avoid damage to the Teflon isulation on the carriage drive cable. This cable supplies -24 volt power to the pen solenoid.

DISASSEMBLY

The Model 565 Plotter is easily disassembled for maintenance or repair. Normal disassembly is limited to removal of the cover, plotter circuit board, and plug-in power supply. No special instructions are required for removal of individual components on the main assembly, the circuit board, or the power supply.

To disassemble the unit, proceed as follows:

1. To remove the cover, unscrew the six screws designated "A" in Figure 5-4 from the base plate.

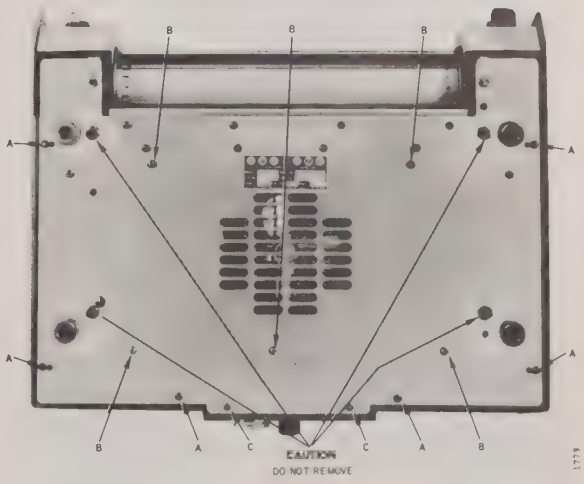


Figure 5-4. Location of Cover and Power Supply Mounting Screws

CAUTION

Remove only those screws designated "A" in Figure 5-4. Removal of screws other than those designated "A" will cause mechanical misalignment or damage.

2. To remove the plotter circuit board, remove the six round-head screws which fasten the circuit board to the mounting standoffs on the main chassis and the power supply chassis. Disengage the assembly from connectors J1 and J2 on the power supply chassis.

3. To remove the power supply chassis, unscrew the two binder head screws designated "C" in Figure 5-4 which fasten the connector bracket to the rear of the base plate. Next remove the two hexagon-head screws which fasten the extended tabs on the power supply chassis to the base. Then remove the five screws designated "B" in Figure 5-4 from the base plate. The power supply chassis may now be removed by pulling straight back.

Note

See Section 6 for additional illustrations. Individual circuit components on the circuit board are identified by reference designations printed on the back side of the board (not shown).

REPLACEMENT AND ADJUSTMENT

The procedures for replacement and adjustment in the following paragraphs should be sufficient to keep the plotter operating smoothly under all but the most abnormal circumstances. Adjustments and replacements for which no procedures are given are either so simple as to be self-evident or so complex that they should not be attempted in the field.

Step Motor Replacement and Adjustment

Location of the carriage and drum step motors, M3 and M4 respectively, is shown in Figures 5-1 and 5-2. To replace either of the step motors, proceed as follows:

1. Disconnect power from the plotter. Remove the cover, circuit board, and power supply as described under Disassembly in this section.

2. Clip lacing twine from the step motor leads to separate them from the wiring harness. Remove the orange, red, brown and white wires from the four limiting resistors mounted on the side of the main assembly. Note these connections carefully so that the new motor can be connected properly.

3. Remove the two Allen-head cap screws which mount the motor to the main assembly. Lift out the motor and primary gear train.

Note

The step motor and its primary gear train are matched at the factory and must be replaced as a complete assembly.

4. Place the new motor and gear train assembly in position, holding the motor so that the protruding pinion gear is below the center axis of the motor.

CATUION

Use care when sliding the motor into position to avoid damaging the plastic gear which mates with the pinion. Do not force the pinion to mesh.

5. Install, but do not tighten, the two Allen-head cap screws which mount the motor to the main assembly.

6. Carefully rotate the motor case clockwise until the pinion meshes with the plastic gear. Maintain clockwise pressure while tightening the two cap screws to prevent backlash in the gear train.

7. Rotate the drum or the carriage drive pulley by hand. Either should move freely, but with perceptible resistance. There should be no perceptible backlash when the drum or carriage is rocked back and forth. If the resistance is excessive, loosen the cap screws and rotate the motor slightly counterclockwise. If backlash is present, rotate the motor slightly clockwise. Again tighten the cap screws.

8. Connect the lead wires from the new motor to the four resistors. Make certain the connections are the same as those on the defective motor removed in step 2:

   Brown — top terminal
   Red — center terminal
   Orange — bottom terminal
   White — bottom terminal (on standoff)

9. Lace the motor leads to the wiring harness. If necessary, attach the power supply and circuit board to the main assembly.

10. Connect ac power to the unit and perform the operational checkout described in the Operational Instructions section. Discontinuities in the 45-degree line drawn with the CARRIAGE FAST RUN and DRUM FAST RUN controls on indicates that the motor is skipping steps because of excessive drag. Loosen the cap screws and rotate the step motor slightly counterclockwise. Excessively noisy operation or pen overshoot on incremental steps indicates backlash. Loosen the cap screws and rotate the motor slightly clockwise.

11. When checkout is completed satisfactorily, make certain the step motor mounting cap screws are tight, then replace the cover on the unit.

Note

For a more accurate check of the step motors, reduce the ac line voltage to 105 vac and connect a square-wave generator to the appropriate pins on P5. The drum and carriage should be capable of continuous stepping action at 300 Hz.

Carriage Cable Replacement

Replacement of a broken or damaged carriage cable can be accomplished in the field with the Carriage Cable Replacement Kit (part no. 90-015). This kit contains all the necessary parts for replacement of all three carriage cables on the Model 565. However, the individual cable segments may be ordered separately by their corresponding part numbers (see Section 6).

The following step-by-step operation describes the procedure for replacing all three carriage cables. Although the replacement of these cables can be performed by one man, a two-man operation greatly simplifies the procedure. Unless otherwise specified, all instructions involving directions (left, right, front, and back sides of the plotter) are based on standing in front of and facing the plotter.

Note

Because much of this procedure must be performed without letting the cables go slack, these instructions should be read through completely and each step visualized before the actual cable replacement is attempted.

As shown in Figure 5-5, the cable segment with the Teflon sleeving over the entire length (part no. 10237-211) is to be connected between the left side of the carriage and the carriage drive pulley. The cable with the Teflon sleeving covering only part of the cable length (part no. 10002-211) is to be connected between the right side of the carriage and the right side of the cable tension spring at the back of the plotter. The completely bare cable (part no. 10104-211) is to be connected between the carriage drive pulley and the other side of the cable tension spring. Installation of these three cables is accomplished as follows:

1. Disconnect power from the plotter and remove the pen assembly.

2. Remove the plotter cover and the six printed circuit board mounting screws. Also remove the circuit board from the chassis. Exercise caution in unplugging the circuit board from its connectors on the plotter base plate.

3. Loosen the two set screws holding the top carriage rod in place and slide the carriage rod out through one end of the plotter frame. It is not necessary to remove the bottom carriage rod.

4. Disconnect all cables to be replaced and discard them.

5. Remove the eyelets loosely mounted on the ends of the two replacement cables which connect to the carriage. Eyelet removal is accomplished by sliding the end of the cable out of the copper Nicopress sleeve. Do not discard the eyelets or sleeves which will be remounted on the cable later in the procedure.

6. Connect the cable with the partial Teflon sleeving (part no. 10002-211) to the right side of the carriage and the cable with the full Teflon sleeving (part no. 10237-211) to the left side of the carriage as shown in Figure 5-6. Thread the end of the cable from which the eyelet was removed through the cable retainer, carriage contact spring, and out through the cable access hole in the side of the carriage frame. Pull the cable all the way through until the knotted end of the cable is tight against the inside edge of the carriage frame. Adjust the cable position until the contact spring position matches the formed carriage pen spring permanently fastened to the carriage as shown in Figure 5-6. Pull the cable tight until the cable seats the retainer firmly in the cable access hole and holds the contact spring firmly in place.

7. Replace the eyelets, previously removed, on the ends of the cable by sliding the Nicopress sleeve back on the cable, looping the cable around the eyelet, and sliding the end of the cable back through the Nicopress sleeve. Continue sliding the cable pigtail through the Nicopress sleeve until the kink in the

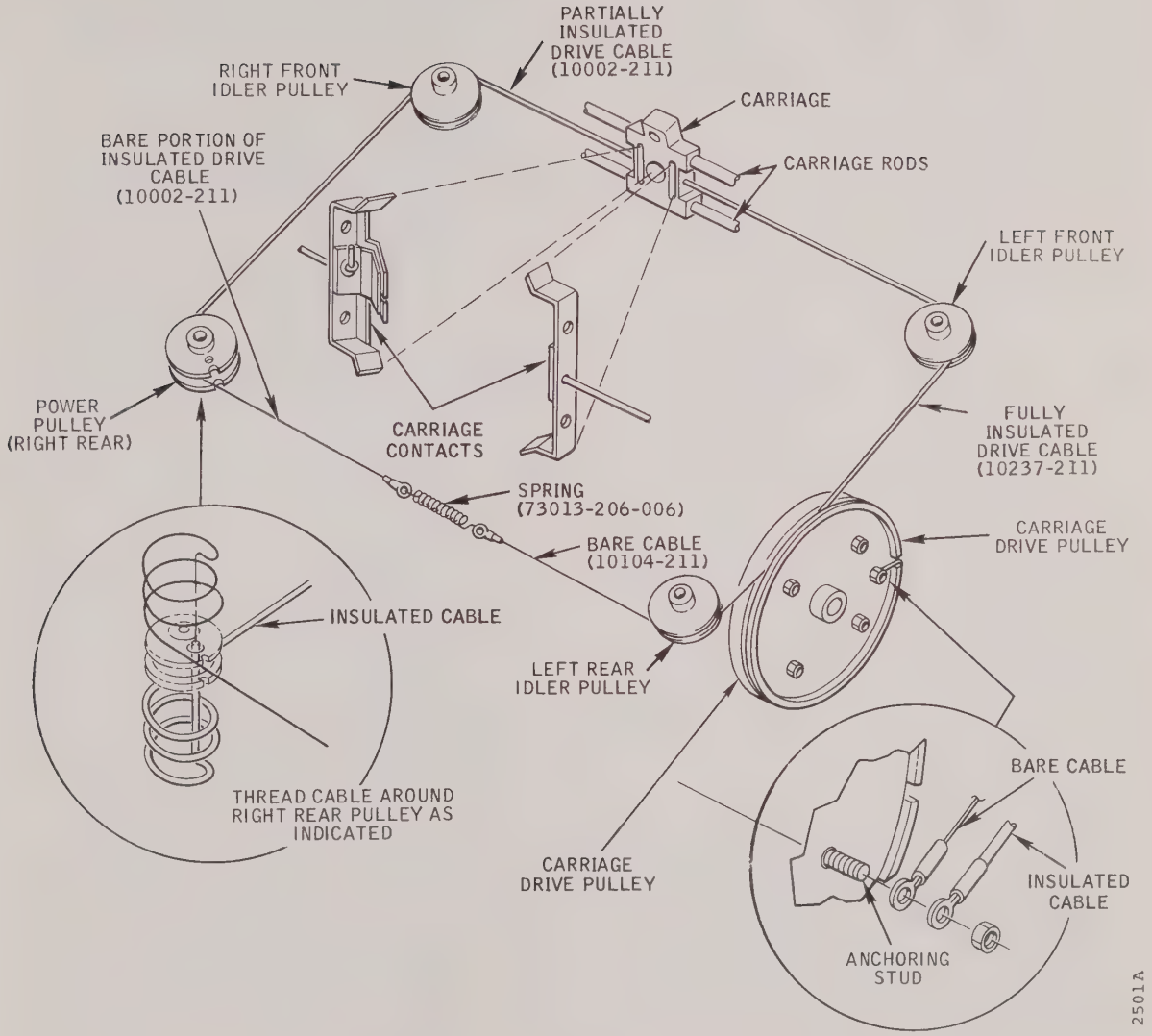


Figure 5-5. Carriage Cable Wiring

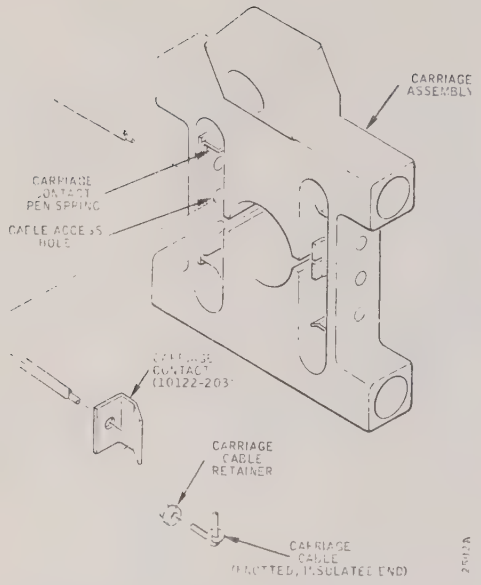


Figure 5-6. Carriage Cable Replacement

cable just slides out of the sleeve (approximately five inches of pigtail should be sticking out of the sleeve). The other side of the cable should then be pulled to tighten the loop around the eyelet. Crimp the Nicopress sleeve into place on the cable using a Nicopress Tool No. 17-2 or equivalent and trim off the cable pigtail. Before reinstalling the carriage on the carriage rod, make sure that the carriage solenoid contacts have not been pushed against the metallic surface of the carriage.

8. Replace the carriage rod through the end plates, limit switches, and carriage, and retighten the two holding set screws, making sure that they bottom on the flat surface at each end of the rods. Check to ensure that the partially insulated cable is on the right side of the carriage and the completely insulated cable is on the left side of the carriage.

9. Rotate the carriage drive pulley until the notch in the outside edge of the pulley flange is positioned in a vertical plane with the plotter base (12 o'clock). The completely bare cable (part no. 10104-211) will be installed on the plotter first (see Figure 5-5).

10. Hook the cadmium plated eyelet over the anchoring stud on the carriage drive pulley (see Figure 5-5) and start the nut on the stud.

11. Route the cable through the notch in the carriage drive pulley flange, and pull the cable to the left (toward the back of the plotter) without moving the pulley until the cable is taut. Then slowly turn the carriage drive pulley in a clockwise direction winding the cable onto the pulley at the outside edge. The pulley should be rotated almost one complete revolution or until the notch and the pulley flange are in the 11 o'clock position. Feed the other end of the cable through the rear opening in the left support, over the idler pulley, and secure the end of the cable to the paper pan with masking tape.

12. Slide the carriage to the extreme right side of the plotter as far as possible and secure it in place with masking tape. Be careful not to get the tape on the carriage rods.

13. Feed the eyelet end of the completely Teflon insulated cable (connected to the left side of the carriage) through the openings in the left carriage limit switch and end support, around the left front idler pulley and back to the carriage drive pulley.

14. To ensure proper operation of the carriage, the Teflon insulation on this cable must be stretched until the insulation extends completely to the Nicopress copper sleeve on the end of the cable. Hold the cable tightly near the carriage with the fingers of one hand. With the other hand, grip the insulation tightly near the outside edge of the end support. Slide the hand toward the eyelet and stretch the insulation. Stop when the Teflon insulation has been stretched just enough to reach the copper Nicopress sleeve. Exercise care when stretching the insulation to prevent it from splitting inside the carriage and pulling out.

15. Again remove the nut from the anchor stud. Place the cable through the notch in the carriage drive pulley and place the eyelet over the anchoring stud on the pulley. Replace the nut and tighten to secure both eyelets. Placing the cable through the notch in the pulley will hold the Teflon insulation in its stretched state. Note that the cable at this point does not wrap around the carriage drive pulley but is only long enough to ride across the top edge of the pulley to the notch in the flange.

16. Remove the masking tape holding the carriage at the right side of the plotter and the masking tape holding the Teflon eyelet of the uninsulated cable to the paper pan at the rear side of the plotter. Standing at the rear of the plotter, pull the uninsulated cable to the extreme left using one hand on the carriage as a drag anchor. Perform this operation slowly making sure the two cables wind on and off the carriage drive pulley properly.

17. With the carriage solidly against the right end plate (as viewed from the rear), open both ends of the cable tension spring and hook one end through the Teflon eyelet of the uninsulated cable. Bend or crimp the end of the spring over to prevent it from slipping out of the eyelet. Tape the cable near the spring to the paper pan to hold tension on the cable.

18. Feed the partially insulated cable connected to the right side of the carriage out through the openings in the limit switch and right support and around the right front idler pulley. Secure the carriage cable and idler pulley in place with masking tape being sure not to get any tape on the carriage rods. Locate the two crimps in the remaining length of cable, one in the insulated portion and the other in the uninsulated portion.

19. Facing the right side of the plotter, feed the cable through the right side of the pulley between the end plate and pulley, around the pulley, and back through the left side of the pulley between the end plate and pulley.

20. Standing at the side of the plotter and looking down on the top of the power pulley, position the pulley so that the hole in the pulley and the corresponding notches are in the 5 o'clock position. Continue wrapping the insulated cable around the pulley, under the first turn, to the notch in the lower edge of the power pulley flange. String the cable through the lower notch in the pulley, positioning the pulley as necessary so that the notch corresponds to the crimp in the insulated portion of the cable. Feed the end of the cable under the pulley, up through the hole in the pulley and out the top, being careful not to twist the cable. The cable should feed through the hole in a natural manner. Position the crimp in the uninsulated portion of the cable in the notch in the top flange of the pulley. Carefully push the insulated cable turns (a little more than one turn) down to the bottom pulley flange.

21. Hold the uninsulated portion of the cable in the right hand. Using the left hand, place the thumb against the turns of cable on the pulley and the index finger underneath the pulley and apply pressure with the thumb and index finger to hold the turns in place. With the right hand, feed the uninsulated portion of the cable around the right side and around the back of the pulley to the left side, pushing the cable turns up toward the top flange as the cable is wound onto the pulley. Slide the left hand up the pulley so that the left hand can be used to hold the cable turns at the top of the pulley in place also. Use the thumb and index finger to hold the cable turns against the pulley at all times while additional turns are wrapped around the pulley. Continue wrapping the uninsulated portion of the cable around the power pulley from right to left, making sure no turns overlap, until the cable runs out. There should be four turns of uninsulated cable on the pulley at this point. It is absolutely essential that no overlapping of turns occurs. If any turns are lost or overlapped or if all tension on the cable is lost so that the turns become loose, the cable must be completely unwound from the power pulley and the procedure repeated from the idler pulley.

22. After the uninsulated portion of the cable has been completely wrapped onto the power pulley, the cable end should be transferred to the left hand while keeping tension on the cable to hold the turns in place. There should be only a short length of cable extending out from the power pulley (away from the plotter) at this point. Remove the tape from the front idler pulley. Using the right hand, pick up the tension spring and carefully remove the masking tape holding the completely bare cable to the paper pan. Gently pull the uninsulated cable with the left hand while easing up the tension on the cable held in the right hand. Continue pulling on the cable with the left hand until approximately six inches of uninsulated cable have been unwound from the power pulley. With masking tape, resecure the completely bare cable connected to the tension spring to the paper pan.

23. Transfer the cable unwound from the power pulley to the right hand. Use the left hand to hold the cable turns on the power pulley in place by placing the thumb and index finger against the power pulley as previously described. Feed the end of the cable around the right side of the pulley, through the opening in the end plate and behind the paper pan. Keeping tension on the cable with the right hand, use the left hand to secure the cable to the paper pan with masking tape.

24. Take the cable attached to the spring in the right hand and the uninsulated end of the other cable with the left hand. Gently pull the cables loose from the masking tape and paper pan. Hook the eyelet of the cable on the left over the loop in the end of the spring and crimp the loop of the spring so that the cable eyelet will not slip off.

25. Standing at the right end of the plotter, gently push the carriage across the length of the plotter as far as possible. Observe that no cable turns overlap or bind

either on the carriage drive pulley or associated idler pulley. Repeat this procedure standing at the other end of the plotter. Watch the power pulley to make certain that no turns overlap or bind.

26. Remove the upper carriage rod as described in Step 3 and lift the carriage up enough so that the cable terminations inside the carriage can be seen. Make sure that the cable retainer is seated firmly in the cable access hold. If not, use a pair of tweezers to move the retainer into the proper position and replace the carriage rod.

Paper Feed Roll Adjustment

When the relative humidity varies for extended periods by more than 10 percent from the recommended 50 percent, the feed drive spool may require adjustment. The adjustment will compensate for expansion or contraction of the paper, which affects the correct alignment of the holes with the drive pins on the drum. To make the adjustment, first remove the cover from the plotter as described under Disassembly and expose the feed drive spool bearing holder and its set screw (Figure 5-7). Using a 3/32-inch Bristol wrench, loosen the set screw so that the drive spool bearing holder can be turned. Screw the bearing holder in or out with a 7/8-inch end wrench to bring the holes in the paper into line with the pins. When the roll is correctly adjusted, there should be no tendency of the paper to wrinkle in the area between the roll and the drum surface. Retighten the set screw only enough to keep the bearing holder from turning freely; overtightening can damage the threads on the bearing holder and will mash the nylon ball that is supposed to protect the threads.

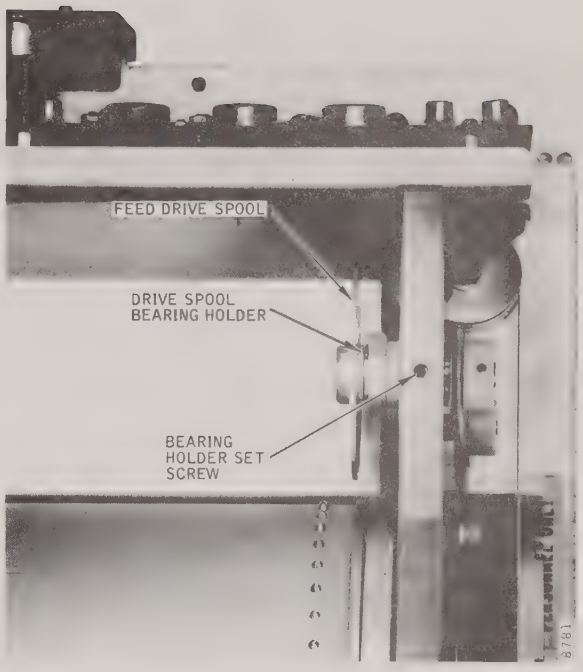


Figure 5-7. Paper Feed Roll Adjustment

TROUBLESHOOTING

The isolation of trouble in the Model 565 plotter requires a comprehensive understanding of the theory of operation described in Section 3. Most troubles can be quickly isolated to one functional circuit by performing the operational checkout described in Section 4.

The trouble then can be isolated to a single stage by performing systematic checks to voltages and waveforms. Table 5-1 is a guide to trouble analysis and Table 5-2 lists voltage test points. Tables 5-3 and 5-4 show drum and carriage control waveforms and pen control waveforms, respectively.

Waveforms illustrated in the following pages are typical for a functional unit and can be obtained by using the manual fast run controls or by connecting a square-wave generator to the appropriate pins on P5. The square-wave generator must be used to obtain the waveforms shown for the pen control circuits.

No special tools are required for troubleshooting the Model 565. The following test equipment is recommended.

- Laboratory-type oscilloscope
- 20,000 ohm-per-volt multimeter
- Square-wave generator, 600 ohms or less output impedance, less than 5 microseconds rise time, 10 volts output (Hewlett-Packard HP211A or equivalent).

CAUTION

Use extreme care when performing tests on the plotter with power on and the cover removed. Accidental short circuits between terminals on the printed circuit board can burn out a diode or transistor. Use care also to avoid shorting the carriage drive cable or its idler pulley to the chassis. Negative 24 vdc is present on both the cable and the pulley when power is on.

TABLE 5-1. TROUBLESHOOTING GUIDE

Symptom	Probable Cause
Unit inoperative, neon power indicator does not light.	• Fuse F1 blown; check for short circuit, then replace fuse. • Defective POWER switch S3. • Defective wiring or connector J7.
Unit inoperative, neon power indicator lights.	• Defective power transformer T1. • Defective power supply component; make voltage and continuity checks; see Figure 3-7.
Both chart drive motors inoperative.	• Defective CHART DRIVE switch S4. • Defective ac wiring.
One chart drive motor inoperative.	• Defective motor; check continuity of windings. • Defective phase-shift component, R6-C8 or R7-C9.
Drum step motor inoperative, carriage operation normal; or carriage motor inoperative, drum operation normal.	• Defective step motor; check continuity of windings. • Open current-limiting resistor or shorted diode; check continuity; see Figure 3-7. • Defective drive transistor or ring counter stage; check Drum and Carriage Control Waveforms in this section.
Drum step motor or carriage step motor inoperative in one direction only; operation normal in opposite direction.	• Defective one-shot circuit; check waveforms. • Defective input trigger circuit; check waveforms and continuity.
Discontinuities in plotting or inaccurate plotting.	• Improper adjustment of step motor; see Step Motor Replacement and Adjustment. • Double stepping due to noise on input signal line; check for excessive power supply ripple; check for defective switching filter components, loose connections, bad solder joints.
Operation normal on automatic plot, abnormal on manual operation.	• Defective control switch or associated wiring.
Operation normal on manual operation, abnormal on automatic plot.	• Defective input trigger circuit or associated wiring.
Pen control circuit inoperative.	• Defective solenoid; check continuity between key pins on pen assembly. • Defective flip-flop or current-control circuit; check waveforms.

TABLE 5-2. VOLTAGE TEST POINTS

Dc Voltage	Test Point	Notes
0	TP1	Circuit ground
- 7.5	TP4	From -6.1 to -7.8 vdc
- 9.0	TP5	1.2 volts or more negative with respect to TP4
+ 1.5	TP2	From +1.7 to +2.2 vdc
+ 3.0	TP6	From +2.5 to +3.5 vdc
-24.0	TP3	From -20 to -25 vdc; no-load ripple less than 4 volts peak-to-peak; load ripple less than 10 volts peak-to-peak

TABLE 5-3. DRUM AND CARRIAGE CONTROL WAVEFORMS

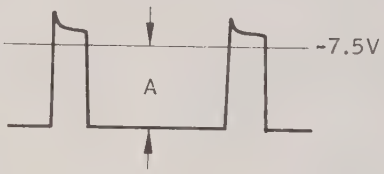
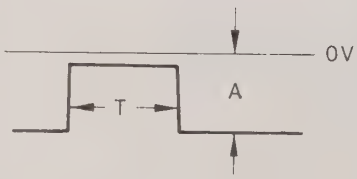
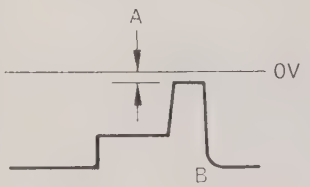
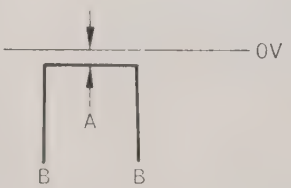
Waveform	Location	Indication
	Base of Q2, Q13, Q22, Q33; triangular pad directly below each transistor	One-shot cutoff bias Scope: 1 v/cm vertical 2 ms/cm horizontal A = greater than 0.6 volt.
	Collector of Q1, Q12, Q21, Q32; top of 1.5K resistor below each transistor	One-shot collector Scope: 5v/cm vertical 500 μs/cm horizontal T = 1200 to 1800 μsec A = approximately 7 volts
	Bottom end of capacitors C4 thru C9, and C21 thru C26 (12 measurements)	Gating waveforms Scope: 5 v/cm vertical 2 ms/cm horizontal A = less than 2 volts B = no overshoot at this point
	Case (collector) of Q5, Q8, Q11, Q25, Q28, Q31	Power transistor saturation Scope: 0.5 v/cm vertical 2 ms/cm horizontal A = less than 0.3 volt B = off scale

TABLE 5-3. DRUM AND CARRIAGE CONTROL WAVEFORMS (Continued)

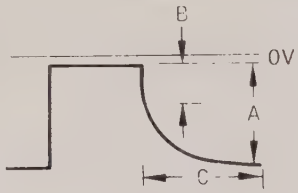
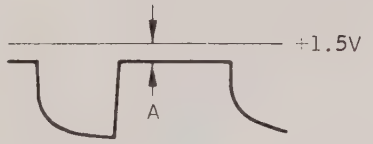
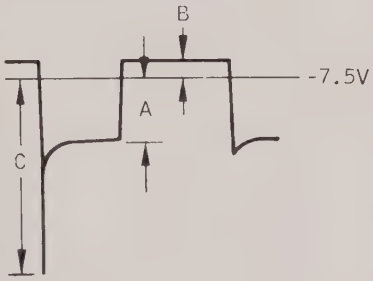
Waveform	Location	Indication
	Case (collector) of Q5, Q8, Q11, Q25, Q28, Q31	Power transistor full waveform Scope: 10v/cm vertical 2 ms/cm horizontal A = approximately 24 volts B = approximately 8 volts C = approximately 5 ms
	Collector of Q4, Q7, Q10, Q24, Q27, Q30; top of 560 ohm 2 watt resistor	Inner stage saturation Scope: 1 v/cm vertical 2 ms/cm horizontal A = less than 0.3 volt
	Base of Q3, Q6, Q9, Q23, Q26, Q29	Ring Counter NPN waveform Scope: 1 v/cm vertical 2 ms/cm horizontal A = more than 1.0 volt B = less than 0.3 volt C = approximately 6 volts

TABLE 5-4. PEN CONTROL WAVEFORMS

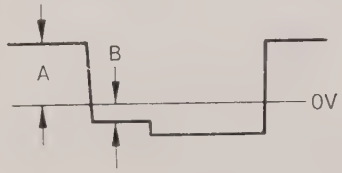
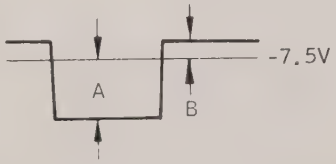
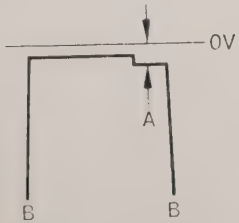
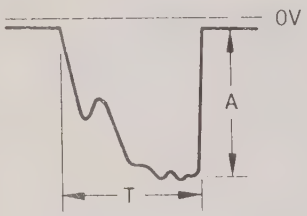
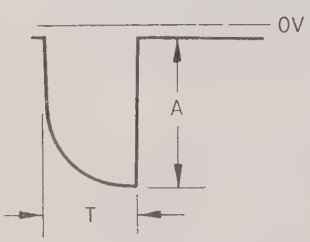
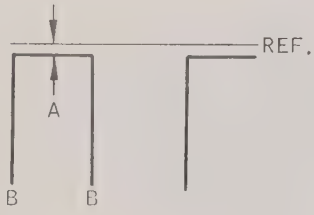
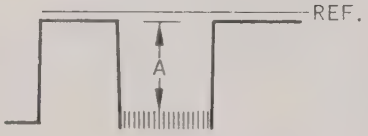
Waveform	Location	Indication
	Base of Q18; bottom of 1.5K resistor	Q18 cutoff bias Scope: 1 v/cm vertical 50 ms/cm horizontal Square-wave generator: 5 Hz A = greater than 0.7 volt B = less than 0.3 volt
	Base of Q19; collector of Q15	Flip-flop saturation Scope: 0.5 v/cm vertical 50 ms/cm horizontal Square-wave generator: 5 Hz A = greater than 0.7 volt B = less than 0.3 volt
	Collector of Q18; top of 560 ohm, 2 watt resistor	Driver saturation Scope: 0.5 v/cm vertical 50 ms/cm horizontal Square-wave generator: 5 Hz A = less than 0.3 volt B = off scale

TABLE 5-4. PEN CONTROL WAVEFORMS (Continued)

Waveform	Location	Indication
	Collector of Q14; top of 3.3K resistors below 560 ohm resistor	Q14 collector voltage Scope: 1.0 v/cm vertical 20 ms/cm horizontal Square-wave generator: 5 Hz A = approximately 3 volts B = less than 0.3 volt
	Top of 10 ohm resistors R58 and R60	Driver current waveform Scope: 0.5 v/cm vertical 20 ms/cm horizontal Square-wave generator: 5 Hz T = 40 to 60 ms A = greater than 0.8 volt
	Top of 10 ohm resistors R58 and R60	Driver short-circuit current Scope: 1.0 v/cm 50 μsec/cm Square-wave generator: 5 Hz Short out CR21 to obtain waveform; when short is removed, waveform should be same as that shown above and pen should lift and lower normally T = less than 100 μsec A = approximately 3.5 volts
	Case (collector) of Q16	Driver saturation Scope: 0.5 v/cm vertical 20 ms/cm horizontal Square-wave generator: 5 Hz Ref: ungrounded end of R58-R60 A = less than 0.3 B = off scale
	Case (collector) of Q16	Driver full waveform Scope: 10 v/cm vertical 50 ms/cm horizontal Square-wave generator: 5 Hz Ref: ungrounded end of R58-R60 A = approximately 24 volts

SECTION 6

PARTS LIST

This section contains illustrated parts lists for the Model 565 Digital Incremental Plotter. When ordering replacement parts, give the complete description as listed in this section, together with the part number.

The step motor, drum assembly, and carriage drive pulley combinations for machines of various step sizes are shown in Table 6-1. Part numbers for various accessory items and loose equipment are listed in Table 6-2.

CAUTION

DO NOT attempt to change step sizes by interchanging step motors. The entire gear train can be severely damaged if a step motor is replaced by one bearing a different part number.

TABLE 6-1. PART NUMBERS DEPENDENT ON STEP SIZE

PLOTTER STEP SIZE	0.010 inch		0.005 inch		0.1 mm	
	I.C. No.	Part No.	I.C. No.	Part No.	I.C. No.	Part No.
PLOTTER	010100-6	20010-101-000	010110-5	20010-101-011	010120-4	20010-101-021
STEP MOTORS	188580-5	10117-301-000	188570-6	10119-301-000	191460-5	10119-301-021
DRUM ASSEMBLY	020290-3	10106-211-000	020290-3	10106-211-000	020290-3	10106-211-000
CARRIAGE DRIVE PULLEY ASSEMBLY	020250-7	10103-211-000	153460-1	10208-211-000	205170-4	10208-211-011

TABLE 6-2. LOOSE EQUIPMENT

Qty	Item	I.C. No.	Part No.
1	Pressurized ballpoint pen kit	283040-4	10082-101-100
1	Line cord	005130-0	10069-401-000
1	Cable connector	063250-5	10021-404-000
1	Plotter cover	064240-5	10306-203-011
1	Paper roll core	016210-1	10891-204-000
1	Roll of chart paper (01 O.B.T.)	034720-3	10002-205-011
2	Roll of chart paper (00 O.B.T.)	034600-7	10001-205-001
2	Instruction manual	231890-5	10018-901-003
	Ballpoint pen kit (optional)	046730-8	10082-101-000
	Liquid ink/ballpoint pen kit (optional)	005150-8	10073-101-000
	Liquid ink/pressurized ballpoint pen kit (optional)	283070-1	10073-101-100
	Liquid ink pen kit (optional)	003930-5	20004-101-000

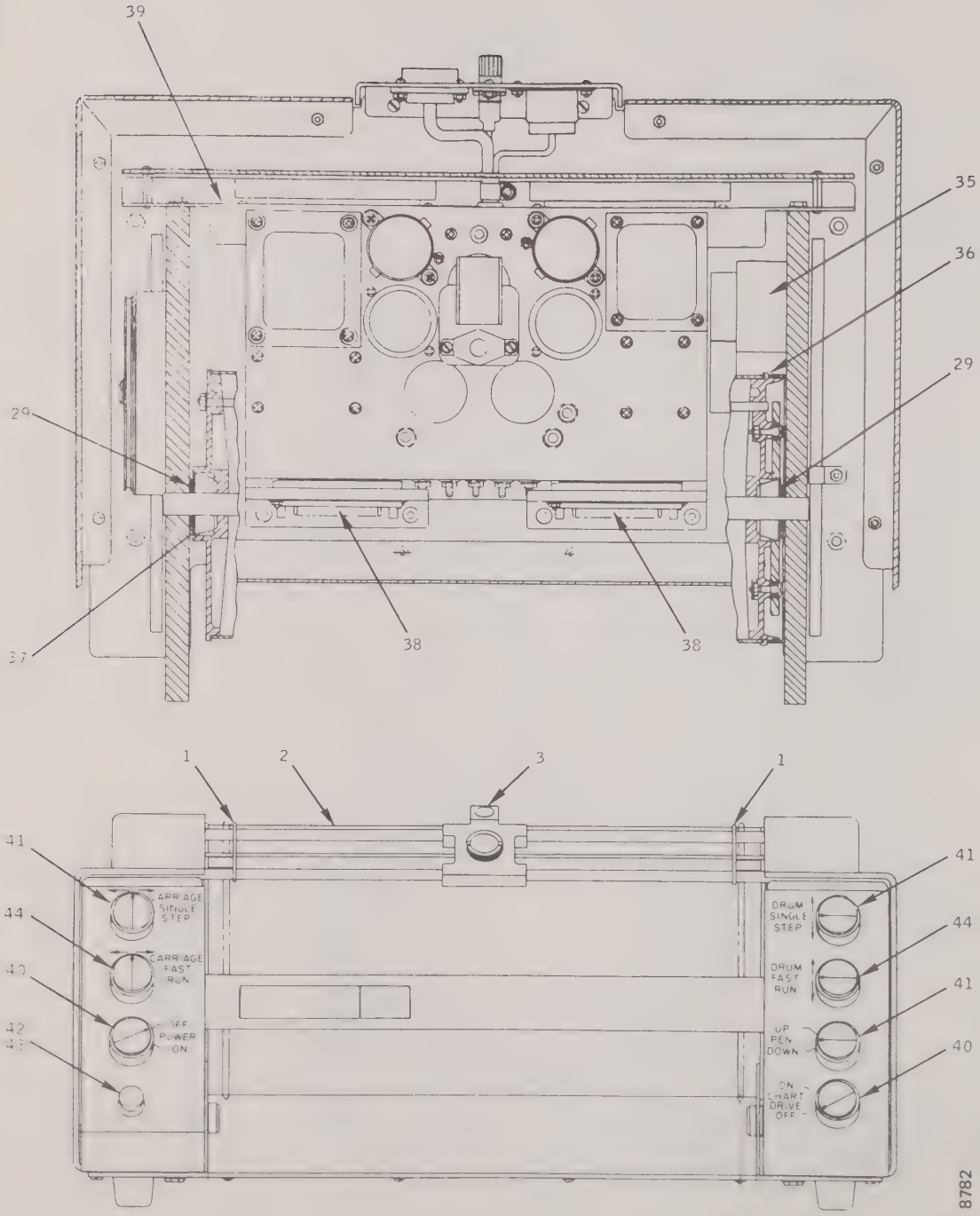


Figure 6-1. Digital Incremental Plotter (Sheet 1 of 2)

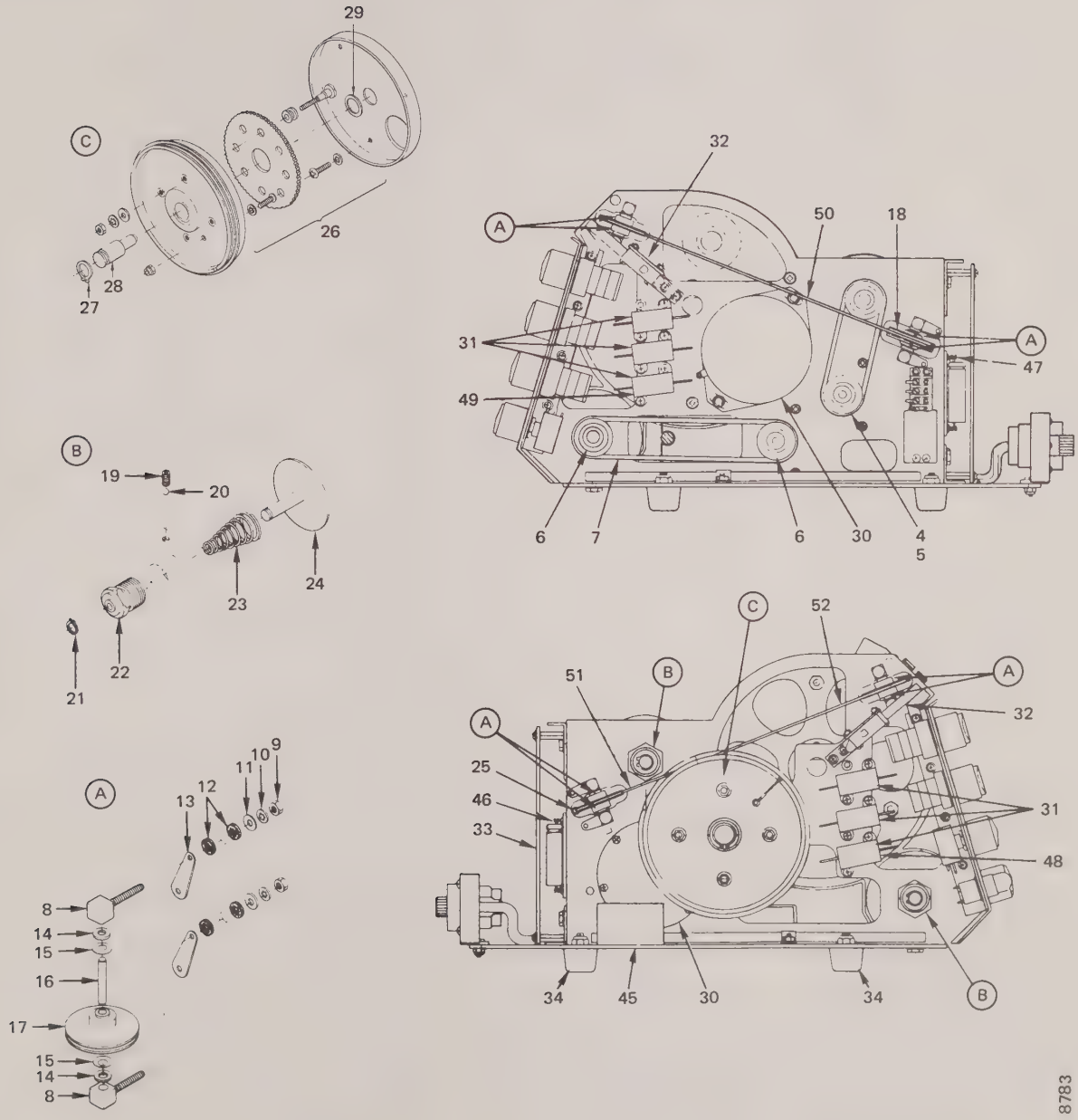
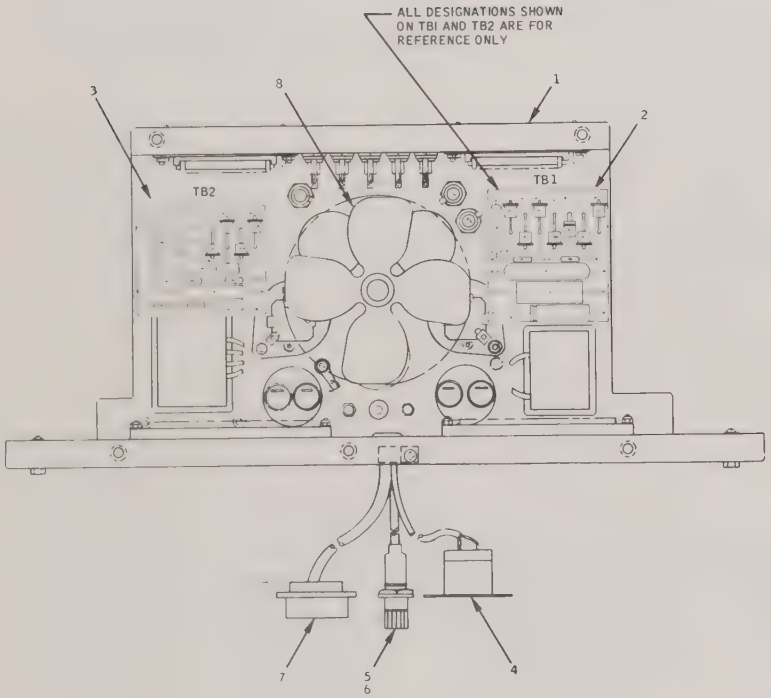


Figure 6-1. Digital Incremental Plotter (Sheet 2 of 2)

INDEX (FIGURE 6-1)	I.C. NUMBER	PART NUMBER	QTY	DESCRIPTION
	See Table 6-1	See Table 6-1	1	DIGITAL INCREMENTAL PLOTTER, Model 565
1	094130-2	56003-206-018	2	. RING, Snap
2	015060-7	10701-204-000	2	. ROD, Carriage
3	020280-4	10105-211-000	1	. CARRIAGE SUBASSEMBLY
4	015130-8	10706-204-000	2	. PULLEY, Paper roll takeup, upper
5	015810-5	73004-206-003	1	. SPRING, Upper pulley
6	015100-1	10705-204-000	2	. PULLEY, Takeup motor, lower
7	015820-4	73004-206-005	1	. SPRING, Lower pulley
8	015270-2	10718-204-000	8	. SUPPORT, Idler pulley shaft
9	173620-6	50003-206-012	8	. NUT, Hex
10	030010-3	74008-206-111	8	. WASHER, Lock
11	029310-0	74002-206-113	8	. WASHER, Plain
12	016360-0	74014-206-111	16	. WASHER, Fiber
13	174070-3	11533-206-005	4	. LUG
14	021950-1	20059-203-000	8	. WASHER
15	021280-3	20058-203-000	8	. WASHER, Spring
16	015300-7	10721-204-000	4	. SHAFT
17	015860-0	10091-211-000	3	. PULLEY, Idler subassembly
18	016030-9	10100-211-000	1	. PULLEY, Special idler subassembly
19	164610-8	60037-206-355	2	. SET SCREW, Cup point, multiple spline
20	020570-8	30001-206-000	4	. BALL, Nylon
21	019050-4	56003-206-031	2	. RING, Snap
22	015910-3	10095-211-000	4	. HOLDER, Bearing
23	015310-6	10886-204-000	2	. SPRING, Paper roll idler spool
24	144110-4	10092-211-000	2	. IDLER SPOOL, Paper roll
25	292310-0	73013-206-006	1	. SPRING, Cad plated
26	See Table 6-1	See Table 6-1	1	. DRIVE PULLEY SUBASSEMBLY
27	070520-2	56003-206-050	1	. RING, Snap
28	015680-2	10730-204-000	1	. SHAFT
29	015940-0	74012-206-411	3	. WASHER, Spring
30	See Table 6-1	See Table 6-1	2	. STEP MOTOR SUBASSEMBLY, M3, M4
31	006710-8	10541-504-308	6	. RESISTOR, 15 ohm, 25w, R11 thru R16
32	033340-1	10602-304-000	2	. SWITCH, S1, S2
33	186560-9	20030-502-000	1	. PLOTTER DRIVER ASSEMBLY, See Figure 6-7 for detail breakdown
34	025950-7	34001-206-000	4	. BUMPER, Rubber
35	022710-8	10104-301-000	2	. MOTOR, 115v, 90 rpm, M1,M2
36	See Table 6-1	See Table 6-1	1	. DRUM ASSEMBLY
37	072550-7	17001-207-001	2	. BEARING
38	015650-5	20011-203-000	2	. SUPPORT, Connector, power supply
39	016040-8	20104-402-000	1	. POWER SUPPLY ASSEMBLY, See Figure 6-2 for detail breakdown
40	013890-9	11501-304-000	2	. SWITCH, Power and Paper, S3,S4
41	016830-2	10203-304-000	3	. SWITCH, Single Step and Pen, S5,S7,S9
42	013780-2	48002-206-001	1	. LAMP ASSEMBLY
43	030370-1	10101-703-000	1	. LAMP, Neon
44	020510-4	10206-304-012	2	. SWITCH, Fast Run, S6, S8
45	012320-8	20001-501-000	1	. R/C NETWORK, FL1
46	071100-2	20018-501-011	1	. TERM. BOARD, see Figure 6-5 for detail breakdown
47	071110-1	20018-501-021	1	. TERM. BOARD, see Figure 6-6 for detail breakdown

INDEX (FIGURE 6-1)	I.C. NUMBER	PART NUMBER	QTY	DESCRIPTION
48	314190-0	10541-504-273	1	. RESISTOR, 3.0 ohm, 25w, R17
49	314200-7	10541-504-250	1	. RESISTOR, 1.0 ohm, 25w, R18
50	005830-5	10002-211-000	1	. CABLE
51	020270-5	10104-211-000	1	. CABLE
52	005820-6	10237-211-000	1	. CABLE


ALL DESIGNATIONS SHOWN ON TBI AND TB2 ARE FOR REFERENCE ONLY
TB2
TB1
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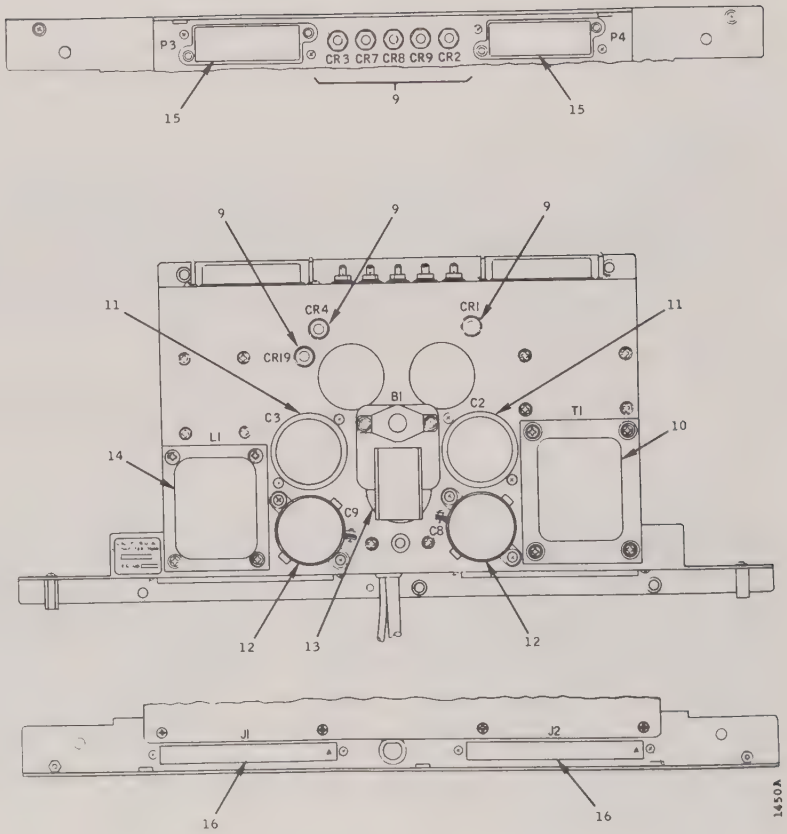
P3
P4
CR3 CR7 CR8 CR9 CR2
9
15
15
CR4
CRI
CRI9
BI
C2
C3
TI
LI
C9
C8
10
11
11
12
13
12
14
JI
J2
16
16
1450A

INDEX (FIGURE 6-2)	I.C. NUMBER	PART NUMBER	QTY	DESCRIPTION
	016040-8	20104-402-000	See Figure 6-1	POWER SUPPLY ASSEMBLY, Digital incremental plotter, see Figure 6-1, item 40 for next higher assembly
1	015320-5	20002-203-000	1	. CHASSIS
2	016130-7	20028-502-000	1	. TERMINAL BOARD ASSEMBLY, No. A, power supply TB1, see Figure 6-3 for detail breakdown
3	016120-8	20009-502-000	1	. TERMINAL BOARD ASSEMBLY, No. B, power supply TB2, see Figure 6-4 for detail breakdown
4	022260-4	70007-404-000	1	. CONNECTOR, Electrical, J7
5	017850-9	40102-304-024	1	. FUSE, 3AG, 2AMP slo-blo, F1
6	018000-0	43002-206-001	1	. HOLDER, Fuse
7	032570-4	10028-404-000	1	. CONNECTOR, Electrical, P5
8	004030-3	10101-301-000	1	. FAN
9	000850-8	20201-506-350	8	. SEMICONDUCTOR DEVICE, Diode, CR1 thru CR4, CR7 thru CR9, CR19
10	006900-5	10009-403-000	1	. TRANSFORMER, T1
11	133550-4	10151-505-408	2	. CAPACITOR, 1500 mfd, 50 vdc, C2, C3
12	031880-8	10702-505-250	2	. CAPACITOR, 1.0 mfd, 330 vdc, C8, C9
13	062040-1	10109-301-000	1	. MOTOR, B1
14	049930-1	10008-403-000	1	. CHOKE, L1
15	017170-2	20009-404-000	2	. CONNECTOR, Electrical, P3, P4
16	013760-4	30028-404-001	2	. CONNECTOR, Electrical, J1, J2

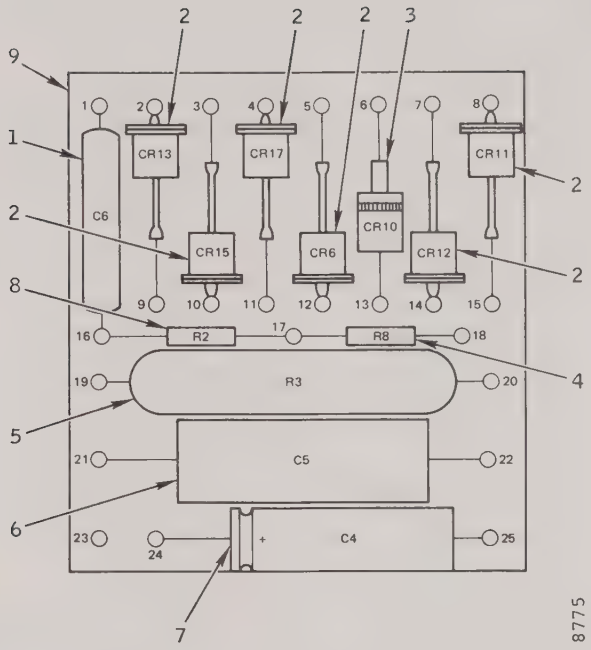

Figure 6-3. Terminal Board Assembly (TB1)

INDEX (FIGURE 6-3)	I.C. NUMBER	PART NUMBER	QTY	DESCRIPTION
	016130-7	20028-502-000	See Figure 6-2	TERMINAL BOARD ASSEMBLY No. A power supply, TB1, see Figure 6-2, item 2 for next higher assembly
1	020920-5	10312-505-175	1	. CAPACITOR, 0.033 mfd ±10%, 200 vdc, C6
2	068890-3	20101-506-334	6	. SEMICONDUCTOR DEVICE, Diode CR6, CR11 thru CR13, CR15, CR17
3	014530-0	30322-506-290	1	. SEMICONDUCTOR DEVICE, Diode Zener, CR10
4	002440-6	10222-504-371	1	. RESISTOR, 270 ohm ±5%, 1/2 w, R8
5	010260-8	10532-504-355	1	. RESISTOR, 125 ohm ±3%, 10w, R3
6	018920-9	11101-505-200	1	. CAPACITOR, 0.1 mfd ±10%, 400 vdc, C5
7	033130-6	10142-505-364	1	. CAPACITOR, 200 mfd 6 vdc, C4
8	243550-1	10621-504-550	1	. RESISTOR, 1 meg ±5%, 1/2 w, R2
9	015610-9	20028-512-000	1	. BOARD, Terminal, No. A

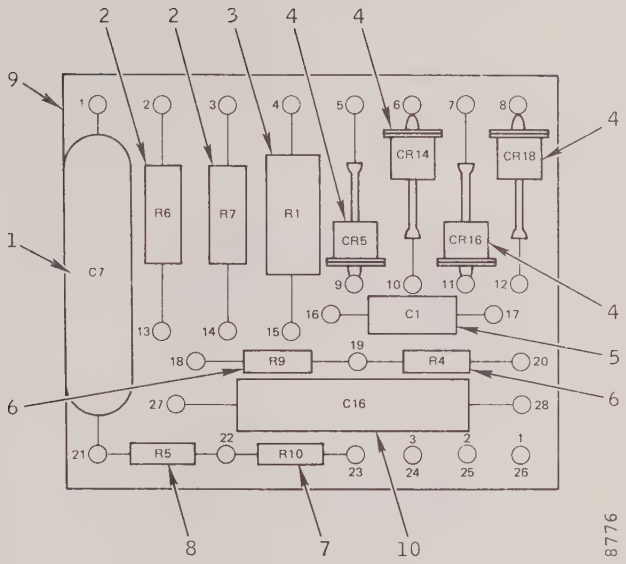

Figure 6-4. Terminal Board Assembly (TB2)

INDEX (FIGURE 6-4)	I.C. NUMBER	PART NUMBER	QTY	DESCRIPTION
	016120-8	20009-502-000	See Figure 6-2	TERMINAL BOARD ASSEMBLY No. B, power supply, TB2, see Figure 6-2, item 3 for next higher assembly
1	018920-9	11101-505-200	1	. CAPACITOR, 0.1 mfd ±10%, 400 vdc, C7
2	131060-6	10231-504-332	2	. RESISTOR, 47 ohm ±5%, 1 w, R6, R7
3	243630-1	10241-504-377	1	. RESISTOR, 360 ohm ±5%, 2w, R1
4	068890-3	20101-506-334	4	. SEMICONDUCTOR DEVICE, Diode, CR5, CR14, CR16, CR18
5	078930-5	10205-505-290	1	. CAPACITOR, 6.8 mfd ±10%, 35 vdc, C1
6	002440-6	10222-504-371	2	. RESISTOR, 270 ohm ±5%, 1/2 w, R4, R9
7	002780-5	10222-504-500	1	. RESISTOR, 100 K ±5%, 1/2 w, R10
8	002510-6	10222-504-400	1	. RESISTOR, 1K ±5%, 1/2 w, R5
9	015630-7	20009-512-000	1	. BOARD, Terminal, No. B
10	204970-8	10315-505-200	1	. CAPACITOR, 0.1 mfd, 600 vdc, C16

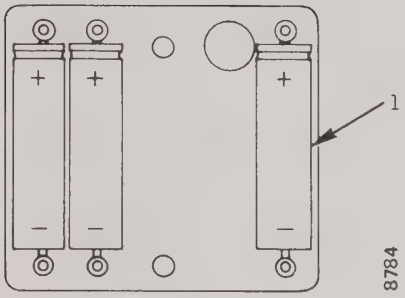

Figure 6-5. Terminal Board Assembly (TB4)

INDEX (FIGURE 6-5)	I.C. NUMBER	PART NUMBER	QTY	DESCRIPTION
	071100-2	20018-501-011	See Figure 6-1	TERMINAL BOARD ASSEMBLY, See Figure 6-1, item 46 for next higher assembly
1	314180-1	10145-505-358	3	. CAPACITOR, 150 mfd, 25 vdc

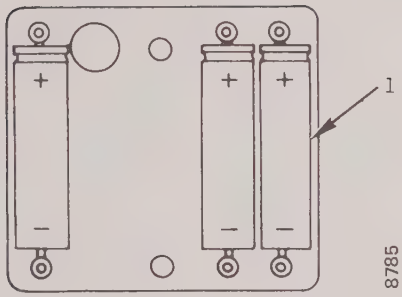

Figure 6-6. Terminal Board Assembly (TB5)

INDEX (FIGURE 6-6)	I.C. NUMBER	PART NUMBER	QTY	DESCRIPTION
	071110-1	20018-501-021	See Figure 6-1	TERMINAL BOARD ASSEMBLY, See Figure 6-1, item 47 for next higher assembly
1	314180-1	10145-505-358	3	. CAPACITOR, 150 mfd, 25 vdc

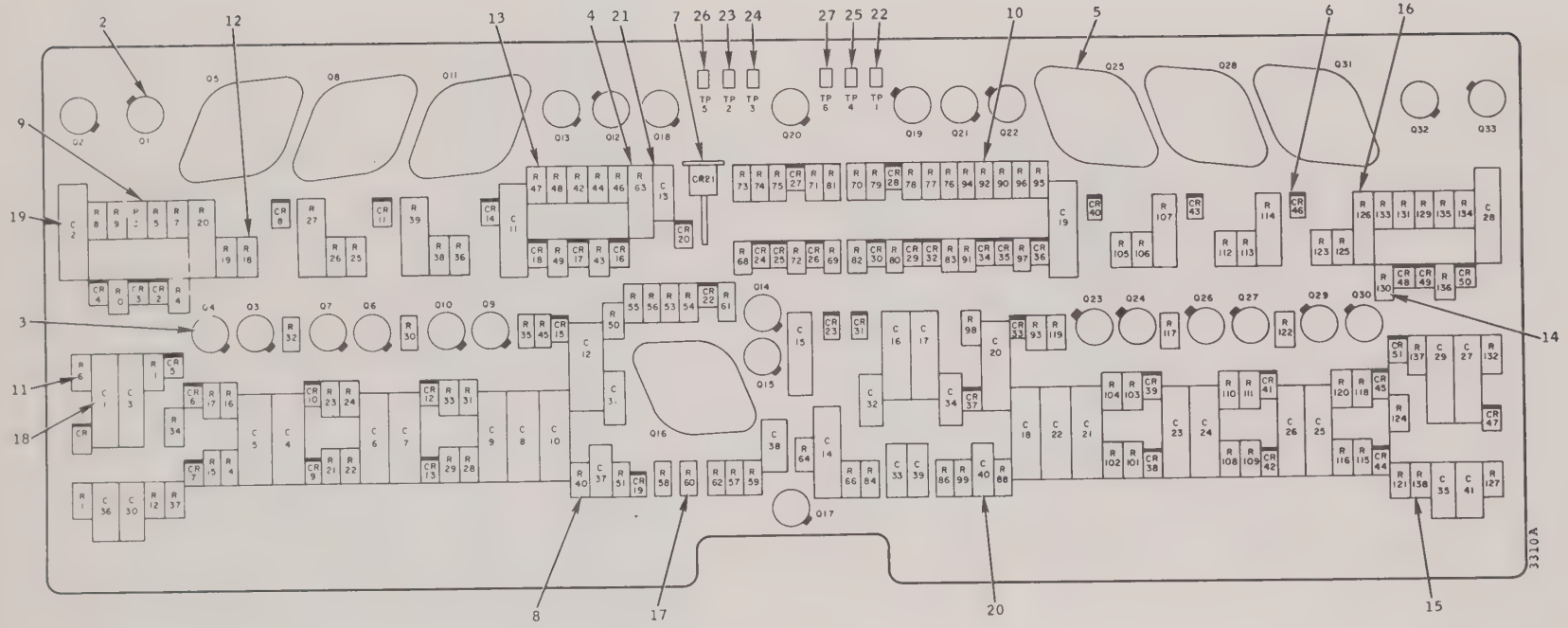

Figure 6-7. Plotter Driver Assembly

INDEX (FIGURE 6-7)	I.C. NUMBER	PART NUMBER	QTY	DESCRIPTION
	186560-9	20030-502-000	See Figure 6-1	PLOTTER DRIVER ASSEMBLY , See Figure 6-1, item 33 for next high assembly.
1	049500-2	30015-404-000	2	. CONNECTOR, P1, P2
2	212440-2	10204-507-000	17	. TRANSISTOR, Q1 thru Q3, Q6, Q9, Q12 Q13, Q17, Q19 thru Q23, Q26, Q29, Q32, Q33
3	017280-9	10104-507-000	9	. TRANSISTOR, Q4, Q7, Q10, Q14, Q15, Q18, Q24, Q27, Q30
4	219180-7	10501-504-375	1	. RESISTOR, 330 ohm ±5%, 2 w, R63
5	017370-8	20105-507-000	7	. TRANSISTOR, Q5, Q8, Q11, Q16, Q25, Q28, Q31
6	068980-2	10101-506-000	50	. DIODE, CR1 thru CR20, CR22 thru CR51
7	032260-2	70301-506-000	1	. DIODE, CR21
8	002510-6	10222-504-400	7	. RESISTOR, 1K ±5%, 1/2 w, R1, R40, R61, R64, R86, R88, R127
9	002610-4	10222-504-440	10	. RESISTOR, 6.8K ±5%, 1/2 w, R3, R42, R69, R70, R75, R78, R81, R82, R90, R129
10	002690-6	10222-504-466	4	. RESISTOR, 22K ±5%, 1/2 w, R5, R44, R92, R131
11	002630-2	10222-504-450	42	. RESISTOR, 10K ±5%, 1/2 w, R6, R14 thru R17, R19, R21 thru R24, R26, R28, R29, R31, R33, R34, R37, R38, R45, R53, R54, R68, R83, R93, R101 thru R104, R106, R108 thru R111, R113, R115, R116, R118, R120, R121, R124, R125, R132
12	002530-4	10222-504-408	19	. RESISTOR, 1.5K ±5%, 1/2 w, R7, R18, R25, R30, R32, R35, R36, R46, R62, R74, R77, R94, R105, R112, R117, R119, R122, R123, R133,
13	002570-0	10222-504-425	18	. RESISTOR, 3.3K ±5%, 1/2 w, R8 thru R10, R47 thru R49, R55 thru R57, R59, R71, R79, R95 thru R97, R134 thru R136
14	002660-9	10222-504-458	4	. RESISTOR, 15K ±5%, 1/2w, R4,R43,R91,R130
15	002550-2	10222-504-416	8	. RESISTOR, 2.2K ±5%, 1/2w, R12,R51,R66,R73, R76,R84,R99,R138
16	132160-3	10241-504-386	6	. RESISTOR, 560 ohm ±5%, 2 w, R20, R27, R39, R104, R114, R126
17	002290-5	10222-504-300	2	. RESISTOR, 10 ohm ±5%, 1/2 w, R58, R60
18	014110-1	10312-505-150	24	. CAPACITOR, 0.01 UF ±10%, 200 vdc, C1, C3 thru C10, C12, C14 thru C18, C20 thru C27, C29
19	014130-9	10312-505-200	4	. CAPACITOR, 0.1 UF ±10%, 200 vdc, C2, C11, C19, C28
20	017890-5	10501-505-394	12	. CAPACITOR, 820 PF ±10%, 500 vdc, C30 thru C41
21	078930-5	10205-505-290	1	. CAPACITOR, 6.8 UF ±10%, 35 vdc, C13
22	066660-2	13501-206-001	1	. JACK, Test brown, TP1

INDEX (FIGURE 6-7)	I.C. NUMBER	PART NUMBER	QTY	DESCRIPTION
23	066650-3	13501-206-002	1	. JACK, Test red, TP2
24	003490-0	13501-206-003	1	. JACK, Test orange, TP3
25	003510-5	13501-206-004	1	. JACK, Test yellow, TP4
26	003480-1	13501-206-005	1	. JACK, Test green, TP5
27	003500-6	13501-206-006	1	. JACK, Test blue, TP6
28	166260-0	12012-206-001	26	. MOUNT, Transistor

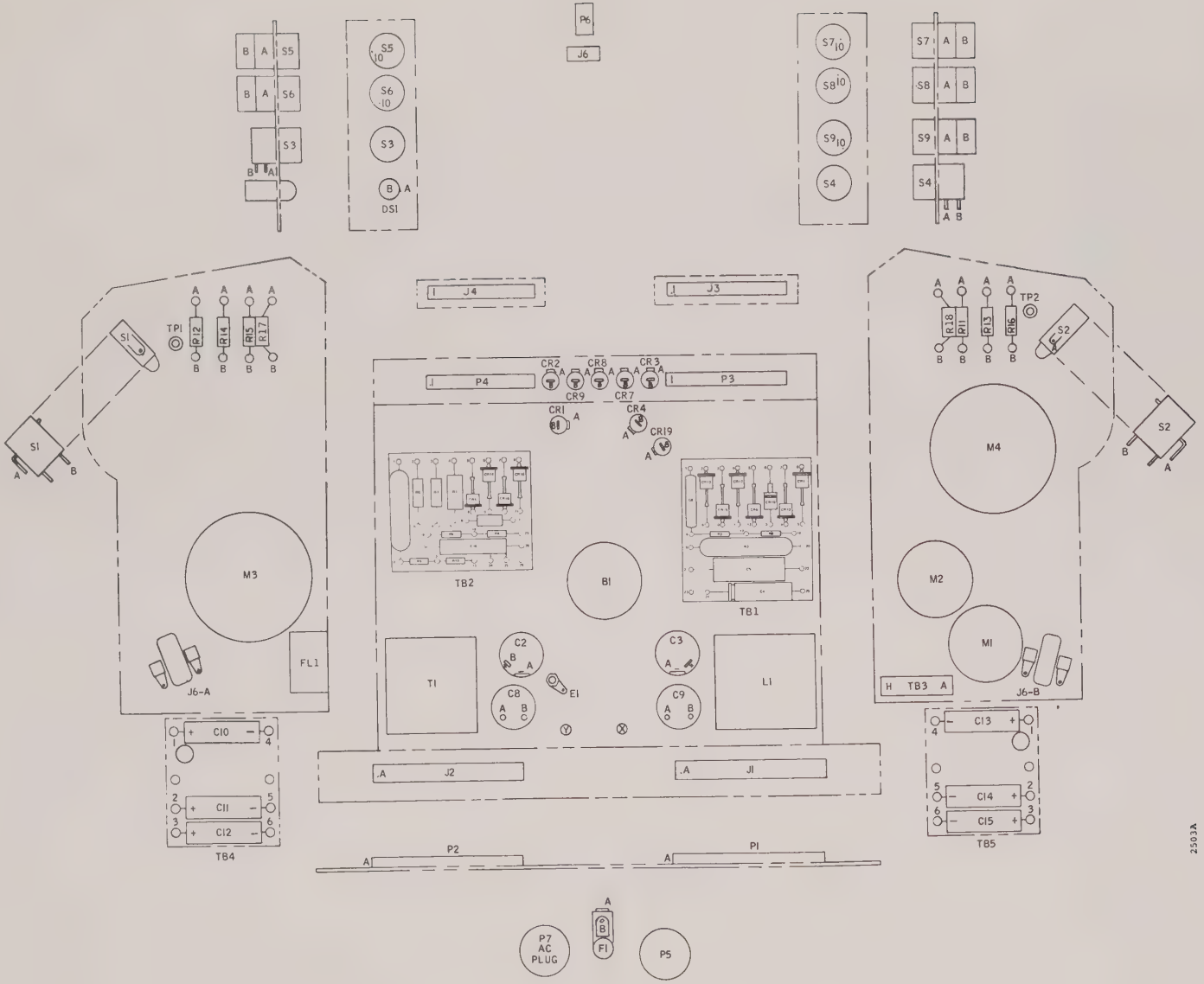

Figure 6-8. Location of Electronic Parts (Plotter as Viewed From Bottom)

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